TREATMENT OF ACUTE POLIOMYELITIS

Third Edition

TREATMENT OF ACUTE POLIOMYELITIS

Edited by

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From the
Departments of Pediatrics Physiology and Physical Medicine
Baylor University College of Medicine
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In Cooperation With
The National Foundation for Infantile Paralysis Inc



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FOREWORD

This syllabus is neither the first nor the last word in the treatment of poliomyelitis The frontispiece suggests that poliomyelitis has been recognized for as long as 3250 years Principles enunciated here reflect our own experience during six years of almost exclusive attention to the management of acute and chronic poliomyelitis and are synthesized with the contributions of others who have dealt with this problem

The material was prepared as a teaching aid to demonstrate the many inter related facets of modern poliomyelitis care which indeed follow the general principles of comprehensive medical management As a compendium it represents aspects of treatment which have evolved from the co-operative endeavors of the many medical disciplines represented in a respiratory center The concise format is designed to emphasize the positive and practical considerations in the care of the patient As a synthesis of experience in poliomyelitis care it necessarily reflects the local practices of those brought together to fulfill the broad needs of the patient These center around expectant treatment as determined by premonitory signs

Provision for the correction of major problems complicating the management of the severely ill patient promotes better overall care and reveals similar problems in other patients For this reason and the preventive importance of every aspect of early care considerable space has been devoted to such conditions

Within the framework of the treatment of this catastrophic disease it should be possible also to discern general principles which are becoming an important part of the entire field of restorative medicine It is hoped that this will have some usefulness in guiding and encouraging that careful individualization which is the constant requirement of medical practice

The editor expresses sincere appreciation to all who collaborated in the preparation of the syllabus and especially to Doctors Hebbel E Hoff Russell J Blattner and Horace L Hodes for invaluable guidance and encouragement Miss Laura Smith deserves special acknowledgment in assisting the editor in collecting preparing and assembling the syllabus

William A Spencer M D

February 1 1956
Houston Texas

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POST ACUTE AND CONVALESCENT TREATMENT OF POLIOMYELITIS

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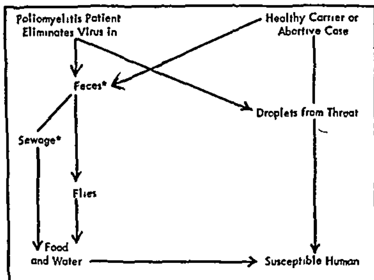
PART II

POST ACUTE AND CONVALESCENT TREATMENT OF POLIOMYELITIS

TREATMENT OF ACUTE POLIOMYELITIS

TREATMENT OF
ACUTE POLIOMYELITIS

EPIDEMIOLOGY OF POLIOMYELITIS



Virus has been isolated

Poliomyelitis is an ancient disease with a world wide distribution The disease may be endemic or epidemic with greater incidence in the warm summer months Multiple infection in families is not unusual There is clinical evidence of polio in more than one member of a family in 5 to 7 per cent of the cases

The poliomyelitis virus is an obligate intracellular parasite which has been classified into three main types Brunhilde (I) Lansing (II) and Leon (III) The virus has been demonstrated in nature in (a) man—body tissues including blood (viremia) oropharyngeal washings stools (b) sewage and (c) flies collected in nature

The reservoir of the virus in nature is probably in man and the transmission is primarily via the intestinal route

The participation of a humoral protective mechanism in infection with poliomyelitis virus has been indicated by the demonstration of viremia increases in serum post infection antibody levels and frequent occurrences of antibodies against one or more strains of the virus in the blood sera of urban populations

Evaluation of field trials of active immunization using formaldehyde treated virus Type I II and III (Salk) has indicated significant protective

effect against paralytic forms of infection in the age groups studied[1] Furthermore serological studies may be of considerable value in furnishing information as to the immunological status of various communities[2] In this fashion it may be possible to define where and in whom vaccination should be carried out.

ULTIMATE DIAGNOSIS OF 1000 SUSPECTED POLIOMYELITIS ADMISSIONS

S W P.R C
(Five-year Period)

	Number	*Per Cent*
Non Poliomyelitis	151	15%
Non Paralytic Poliomyelitis*	258	26%
Paralytic Poliomyelitis	591	59%
Total	1000	100%

Diagnosis not changed on 1 year follow up

All who have had experience with infections caused by the poliomyelitis virus are aware of the many complexities encountered in diagnosing the disease These are greatly enhanced by pressures exerted on the physician by an apprehensive public However there is no infallible method available at the present time for making a definite diagnosis of poliomyelitis during the earlier phases of the infection

Diseases most commonly simulating poliomyelitis include The various encephalitides and meningitides infectious neuronitis cerebral and spinal neoplasms and abscesses pulmonary infections specific diseases of muscles bones and joints and acute emotional disturbances such as hysteria

The list of specific diseases which can be confused with acute poliomyelitis is long and varied Nonetheless this protean disease has certain clinical features which are sufficiently consistent to merit emphasis

FINAL DIAGNOSIS OF NON POLIOMYELITIS ADMISSIONS

TOTAL 151

78 CNS INFECTIONS

- 27 encephalitis etiol not det
- 6 mumps encephalitis
- 1 pertussis encephalitis
- 1 post vaccinal encephalitis
- 1 herpes zoster encephalitis
- 1 post rabies vaccinal encephalitis
- 10 pyogenic meningitis
- 5 lymphocytic choriomeningitis
- 3 tuberculous meningitis
- 1 herpes simplex meningo encephalitis
- 1 arachnoiditis
- 4 cerebral abscess
- 1 acute pyogenic cerebritis
- 1 CNS syphilis
- 11 infectious neuronitis
- 3 Coxsackie virus infection?
- 1 tetanus

16 OTHER CNS DISORDERS

- 4 brain tumor
- 4 cerebral vascular accident
- 1 idiopathic epilepsy
- 1 infantile hemiplegia
- 1 acute cerebellar ataxia
- 2 acute meningo myelitis etiol undet
- 1 spinal cord neoplasm
- 1 general muscular rigidity
- 1 post partum post L P headache

26 MISCELLANEOUS INFECTIONS

- 3 pneumonia
- 2 influenza
- 2 U R I
- 2 roseola
- 3 otitis media
- 1 tonsilitis
- 1 sinus infection
- 2 gastroenteritis
- 1 infectious mononucleosis
- 9 infection etiol unknown
- 1 serum sickness

31 OTHER

- 2 rheumatoid arthritis
- 1 arthralgia
- 1 rheumatic fever
- 1 sprain lumbar muscles
- 1 trauma left arm
- 1 neuropathy
- 1 cervical adenopathy
- 1 tenosynovitis
- 2 infantile scurvy
- 7 hysteria
- 1 angioneurotic edema
- 12 not determined

The above diagnoses were those made on patients admitted to the hospital following outpatient admission screening in most instances It is apparent that many disease entities mimic poliomyelitis so that careful historical and physical examinations are needed to identify poliomyelitis like disorders

ULTIMATE DIAGNOSIS OF 1059 POLIOMYELITIS CASES

S.W.P.R.C.
(Five-year Period)

	No. Patients	*Per Cent*
Non Paralytic	318	30
Paralytic	741	70
TOTAL POLIOMYELITIS	1059	100

Spinal Type	519	70
Bulbar	79	10
Bulbospinal	143	20
TOTAL PARALYTIC	741	100

Paralytic Poliomyelitis	741	100
Severe Poliomyelitis	279	37

Severe Poliomyelitis	279	100
Fatal Poliomyelitis	50	18

Including D.O.A.'s

The percentage of reported poliomyelitis patients with the non paralytic form of the disease varies from 30 to 60 per cent. Because of this comparative mortality figures are valueless if non paralytic patients are included. The actual incidence of non paralytic disease in a hospital experience depends upon variability of the disease diagnostic criteria, admission policy and thoroughness of the follow up evaluation. The low incidence of non paralytic disease in this example is a result of admission screening and the centralization of severely involved patients in an acute treatment center.

Severe disease is not necessarily synonymous with "bulbar" poliomyelitis if all of the conditions posing a serious threat to life are included.

DIAGNOSTIC CRITERIA FOR ACUTE POLIOMYELITIS

SUGGESTIVE

History of mild pharyngitis
Fever of moderate degree without coryza cough or diarrhea
Headache (Especially significant in children)
Vomiting
Malaise out of proportion to physical findings
Meningismus stiff and painful neck and back inability to flex spine which is "poker like"
Head drops back when shoulders are lifted
"Tripod *sitting position inflexible lumbar spine in infants*
Muscle pain and tenderness especially trunk and hamstrings (not unilateral)
Reflexes obtainable occasionally hyperactive

CONFIRMATORY

Flaccid muscle paralysis often asymmetrical and regional with involvement of several muscles of the same segment
Absent tendon reflexes in the affected areas
Abnormal spinal fluid cells more than 10 usually less than 500/cu mm polys early lymphs later Pandy positive slight to moderate increase in protein content normal sugar con tent no bacteria on smear and culture Spinal fluid pressure may be normal or slightly elevated
Absence of sensory disturbances except transient hyperesthesia

POSITIVE

Isolation of virus in the presence of the above
Increasing antibody titer during the course of the disease

A definite program of management is indicated by the acceptance of poliomyelitis as a probable diagnosis It is extremely important to ascertain the course of the disease by careful observation Detection of impairment of vital body functions may determine survival

Beware of exhausting the patient *just for the purpose* of elaborating the diagnosis through repeated lumbar punctures vein punctures and extensive physical examination

Normal cerebrospinal fluid findings occur in less than 5 per cent of cases with other confirmatory evidence of poliomyelitis [8]

INITIAL MANAGEMENT

REST IS OBLIGATORY!

Strict bed rest for a minimum of two weeks

Accurate measurement of temperature pulse respirations and blood pressure every four waking hours during febrile phase More frequent observations are indicated by occurrence of serious findings

Correct dehydration and maintain fluid and electrolyte balance

Do not mask crucial signs and symptoms or depress protective reflexes by sedation

Exhausting procedures such as repeated and detailed muscle examination are contraindicated and may be harmful

Reserve antibiotics and chemotherapeutic agents for secondary infection

Assist patient to assume comfortable and relaxed positions to relieve back pain and general discomfort Change position at least every two waking hours

Support weakened parts with towel rolls foam rubber pads and protect bony prominences with extra padding Avoid habitual positions Perform range of motion during daily bed baths

Position feet in high topped tennis shoes fixed to a plywood board (See page 14)

Minimize muscular pain Avoid accidental stretching during routine care and *handle extremities at the joints instead of muscle bellies*

Most infectious diseases require bed rest during the febrile and immediate post febrile period Furthermore neuromuscular and central nervous system disorders which result in muscular weakness appear to have the best outcome if bed rest is instituted as soon as possible Achievement of rest requires attention to emotional and social problems as well as physical care Emotional reassurance medical orientation of the patient and his family and assistance in overcoming social problems arising from disruption of the family unit may be as important as physical measures

It appears likely that fatigue as a result of travel and physical exertion[4] as well as respiratory and metabolic disturbances may seriously compromise the outlook for the acutely ill patient

GENERAL CONSIDERATIONS IN THE ACUTE PHASE

MEASURES TO PRESERVE WELL-BEING OF ALL PATIENTS

- Stimulate and maintain personal interests and intellectual activity
- Encourage family contacts by letter and telephone during isolation and personal visits thereafter
- Maintain nutrition by adequate caloric intake through an attractive balanced diet
- Keep skin clean and dry—daily bath scalp and oral care
- Change body position frequently
- Promote normal bowel and bladder function

There are no specific therapeutic agents which will favorably alter the course of motor neurone involvement Pharmacological agents such as ACTH and cortisone on the other hand appear to enhance infection in experimental animals[5] and therefore are contraindicated

The degree of muscular involvement and conditions such as dehydration vomiting urinary bladder retention acute nutritional disturbances severe pain and tenderness alter the medical program of management

Comprehensive care of the patient requires attention to small and large events as well as detailed treatment which taken together determines the outcome The patient immobilized because of paralysis or its treatment cannot tolerate the accumulation of apparently minor physical and psychological insults These insults which may occur from onset condition the patient s acceptance and capability for optimal rehabilitation

IMMEDIATE POST ACUTE MANAGEMENT

INDIVIDUALIZE AND BALANCE REST AND PHYSICAL ACTIVITY

Encourage periods of near normal body alignment within the limits of comfort Do not enforce strict anatomical alignment but work towards good alignment 18 hours a day

Use moist heat (hot packs) to painful areas if positioning is not effective Do not pack patients with body temperature elevations greater than 101° F (rectal) Correct increased fluid and electrolyte losses due to increased perspiration Packing more than 20 minutes and more than four times a day is rarely necessary

Forty eight hours after the patient is afebrile institute daily physical therapy beginning with range of motion and gentle stretching Intensive physical therapy before this time is unnecessary and may be harmful

Provide comfortable and easily applied splints to sustain proper functional position of the hands Place wedge pillows under axilla if shoulder girdle weakness is present

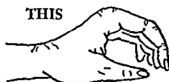
As tightness and resistance to movement subside during treatment and muscle balance is gained progressive sitting and weight bearing (tilt table standing bed) programs are started

Increasing tightness weakness or imbalance may be an indication of premature and excessive sitting and walking

Neither omission nor over emphasis of these factors is desirable Careful attention and individualization to small details eliminates complications and deformities which may require painful corrective measures Neglect or over treatment may produce irreversible trauma contractures and deformities which need not accompany the early results of the disease

EARLY CARE OF PARALYTIC UPPER EXTREMITY

THIS



NOT THIS



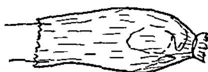
Change hand elbow and shoulder position frequently
Avoid constant position of hands on chest or at sides
Alternately supinate and pronate forearm
Maintain web space of thumb, and keep thumb in position of *opposition*
Maintain arch of palm and place hand in the functional position of slight dorsi flexion and ulnar deviation of the wrist and moderate flexion of the fingers

USEFUL TEMPORARY POSITIONING DEVICES

For the hand



Ace bandage or gauze roll



Stockinet "glove" with ball bandage roll wad of paper foam rubber etc in the palm



Wrist corset or cock up splint



Ball with finger ring

For the shoulder and arm triangular pillows may be used for moderate shoulder abduction foam rubber doughnuts to protect the olecranon process and a small inter scapular pillow prevents scapular abduction so characteristic of prolonged recumbency

A useful hand is the key to functional independence Adequate range of motion at the elbow and shoulder are necessary to place the hand in a position for function Even minimal muscle power salvaged in the upper extremity can be put to functional use with the application of individualized assistive devices if fixed deformities have been prevented

Daily range of motion and stretching should be instituted during the post acute stage to maintain and gain mobility the hand should be protectively positioned through the use of a simple comfortable contrivance the arm should be repositioned at frequent intervals to maintain good alignment.

Later in the post acute stage the individual needs are studied and more permanent splints may be ordered Utilize temporary measures while waiting for application of these permanent splints since this is the time when long range patterns of controlled movement are being set [6]

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THIS



NOT THIS



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SIGNS AND SYMPTOMS OF SERIOUS POLIOMYELITIS

PROVOCATIVE CONDITIONS

- Pregnancy
- Physical exhaustion during prodomal phase
- Development of paralytic poliomyelitis in the adolescent and young adult

SUGGESTIVE SIGNS

- Rapid onset and progression of paralysis
- Paralytic involvement of the shoulder girdle
- Involvement of any cranial nerve
- "Toxic" appearance with flushed facies perioral pallor and conjunctival suffusion
- Higher temperature elevation without marked diurnal variation.
- Tachycardia
- Moderate hypertension
- Nystagmoid jerky ocular movements on lateral gaze and fixation (opsoclonia)
- Irritability restlessness fitful sleep apprehension progressing *to lethargy or severe anxiety and confusion*

CONFIRMATORY

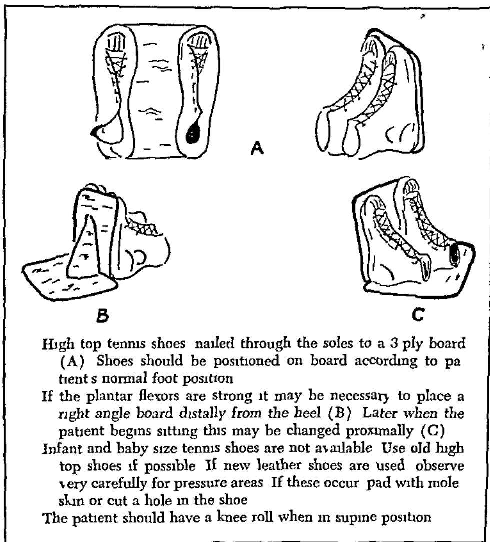
- Respiratory muscle paralysis
- Swallowing impairment
- Respiratory circulatory and other autonomic regulatory disturbances
- Pulmonary complications

Recognition of serious poliomyelitis is not easy in the early stages of infection An apparently mild illness may progress rapidly It is imperative to observe continuously all poliomyelitis patients with any of the suggestive signs and symptoms In no other way is it possible to anticipate serious complications and treat them before irreversible deterioration has occurred

A history of unusual physical exhaustion during the prodomal febrile phase often precedes extensive muscular paralysis The occurrence of serious disease in the adolescent and young adult patient is twice as frequent as in the pre school child For this reason such patients with suspect poliomyelitis should be observed in the hospital.

Do not confuse and obscure evaluation of patients with evidence of serious illness by sedation which masks crucial symptoms or inhibits protective reflexes

PROPER POSITIONING OF THE FEET (TENNIS SHOES ON A BOARD)



High top tennis shoes nailed through the soles to a 3 ply board (A) Shoes should be positioned on board according to patient s normal foot position

If the plantar flexors are strong it may be necessary to place a *right angle board distally from the heel* (B) *Later when the* patient begins sitting this may be changed proximally (C)

Infant and baby size tennis shoes are not available Use old high top shoes if possible If new leather shoes are used observe very carefully for pressure areas If these occur pad with mole skin or cut a hole in the shoe

The patient should have a knee roll when in supine position

This type of foot support provides advantages over the conventional bed foot board It is attached to the patient and he can change position and be moved *while still maintaining* good alignment This type of splint maintains foot and lower extremity alignment by preventing shortening of the triceps *surae and plantar fascia* supporting weakness in the dorsi flexors of the ankle and minimizing rotation at the hip It is inexpensive easily applied comfortable and can be used from the onset of bed rest During the acute stage patients wear them continuously because they are comfortable Deformities arising from lack of proper positioning have not been observed

SIGNS AND SYMPTOMS OF RESPIRATORY MUSCLE PARALYSIS

EARLY RESPIRATORY MUSCLE INVOLVEMENT IS NOT OBVIOUS

SUGGESTIVE

Involvement of the pectoral musculature especially the deltoid group
Increase in respiratory rate
Shallow respirations
Decreased ability to protrude abdomen (diaphragm)
Diminished elevation of thorax on deep breath and abdominal splinting (intercostals)
Decreased or unequal upper abdominal movement with "sniffing" (diaphragm)
Paradoxical abdominal or thoracic movement on deep breathing
Inability to tighten abdominal muscles on raising head.
Poor or absent cough (abdominal muscle paralysis)

CONFIRMATORY

Decreased or absent breath sounds on auscultation
Fluoroscopic evidence of diminished or absent range of movement of diaphragm and intercostals diaphragm lag tenting asymmetrical excursion paradoxical movement
Decreasing vital capacity which is below minimum normal values

DECREASING RESPIRATORY MUSCLE ACTIVITY IS THE INDICATION FOR RESPIRATORY ASSISTANCE

Detection and anticipatory treatment of conditions leading to respiratory insufficiency are most useful in the clinical management of the patient. Most commonly respiratory insufficiency results from respiratory muscle paralysis However the degree of respiratory insufficiency which insidiously compromises the patient s well being is extremely difficult to recognize On the other hand, the provocative muscle paralysis may be readily detected and objectively measured Therefore the safe use of mechanical assistance is determined by the conditions leading to difficulty rather than the estimation of the adequacy of breathing

OCCURRENCE OF CONDITIONS ENDANGERING LIFE IN ACUTE POLIOMYELITIS

SWPRC
(Five Year Period)

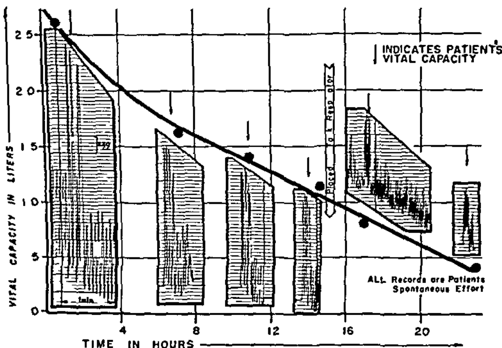
*Condition**	*Incidence**	% *Patients*
Total severely ill patients	279	100
Respiratory muscle paralysis	198	71
Swallowing impairment	147	53
Disturbances of circulatory and respiratory regulation	135	48
Pulmonary edema	12	4

* Combinations of these conditions in a single patient are not indicated in the above chart.

The occurrence of serious complications in 37 per cent of paralytic patients is somewhat larger than the usual incidence of 20-30 per cent because of selective admission in a Respiratory Center Nevertheless the frequency of such conditions in the course of acute illness emphasizes the importance of their detection and treatment for the preservation of life This is a separate problem from the ultimate disability which may result from the residual muscular paralysis

Respiratory muscle paralysis is the most common cause of respiratory insufficiency Impairment of swallowing is next in frequency Prompt treat ment of these two conditions accounts for the largest reduction in mortality In the majority of instances proper treatment does not depend upon the pathogenesis of these conditions nor the fact that insufficiency has less precise physiological than clinical meaning

DECREASING VITAL CAPACITY IN ACUTE POLIOMYELITIS



Patient 29 year old male estimated normal vital capacity 4 7 liters This figure illustrates the rapid and progressive decline in vital capacity observed in the majority of cooperative poliomyelitis patients with respiratory muscle paralysis The actual vital capacity maneuver was recorded with a closed circuit recording spirometer with carbon dioxide absorption and is indicated by arrows The individual spirometer records progress from right to left

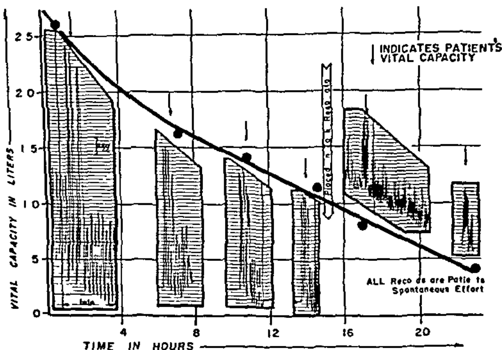
A successive increase in spontaneous respiratory rate coincident with more shallow depth of breathing is indicated in the first and next to the last records In the cooperative patient 7 years of age and older DECREASING VITAL CAPACITY IS THE BEST CLINICAL INDICATION FOR RESPIRATORY ASSISTANCE

Collins Warren E Respirometer*

Artificial respiration is eventually necessary for 80 per cent of all patients with respiratory muscle paralysis Why wait for profound asphyxia to confirm the presence of respiratory failure? There is no evidence that artificial respiration increases respiratory muscle paralysis when otherwise it promotes rest by diminishing the work of breathing

The alarming symptoms of asphyxia should not be blamed upon poliomyelitis until effective ventilatory assistance proves to be inadequate Assistance should not be withheld to prove asphyxia will occur

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Collins Warren E Respirometer"

INDICATIONS FOR TANK RESPIRATOR IN RESPIRATORY MUSCLE PARALYSIS

ARTIFICIAL RESPIRATION IS URGENTLY INDICATED BY DECREASED VITAL CAPACITY!

Adults	1500 – 1000 ml
Adolescents	1000 – 750 ml
Children	less than 500 ml

Vital capacity values may be obtained with recording basal metabolism machines (if value is 2500 ml or less) ventilation meters spirometers and vital capacity meters *

Initial measurements may be low because of poor cooperation due to apprehension

Low values are determined by comparison with minimal observed values (See Appendix.)

Physical examination and fluoroscopy establish progressing respiratory muscle paralysis in young children and infants who cannot cooperate with vital capacity measurements

TANK RESPIRATOR IS THE DEVICE OF CHOICE!

The progressive decline of a maximum effort such as the vital capacity is the most useful and objective single indication for artificial respiration Early use of the respirator promotes respiratory muscular rest since synchronization of the patient s spontaneous efforts and then complete acceptance of the respirator is easier to achieve at this time

Furthermore early use of the respirator while the patient is cooperative permits him to learn how to protect his airway Introduction of artificial respiration while there is still some voluntary breathing ability minimizes the emergency nature of the apnea which may follow in the natural course of the disease Similarly withholding artificial respiration may lead to a terminal state in which *its use is unnecessarily complicated or even ineffective*

The tank respirator alone has the range of ventilatory effectiveness which may be necessary in severely ill patients Its reliability and simplicity are particularly valuable when it is used for the totally apneic patient who should not be subjected to any respiratory interruption. Such patients can

* Bennett Ventilation Meter obtained from J J Monaghan Co Inc., Denver Colorado
Collins "Vitalometer" or "Respirometer" from Warren E Collins Inc., Boston Massachusetts
Emerson Ventilation Meter from J H Emerson Co., Cambridge, Massachusetts

not tolerate under ventilation Under ventilation may complicate the use of auxiliary devices such as the cuirass respirator and rocking bed because they are less effective and are not suitable for continuous artificial respira tion in the initial stages of treatment

Adjustment of cuirass respirators is difficult The fit and seal of the shell are hard to maintain and prolonged use may cause discomfort from chafing of the skin On the other hand such devices especially the more efficient ones with shells covering the abdomen are useful for brief periods of respite from the tank respirator During these periods nursing care including linen changes bed baths range of motion etc. may be carried out Similarly, positive pressure breathing attachments and positive pressure domes on the tank can simplify routine care

In some instances the rocking bed may be contraindicated and harmful e g use in the presence of swallowing impairment pulmonary complication and congestive heart failure In the latter case the increased cardiac venous return produced by the motion of the bed may seriously overload a failing heart

Some types of intermittent positive pressure breathing devices may be fully as effective for pulmonary ventilation as the tank respirator However their continuous use requires either a tracheotomy or an indwelling endotracheal tube of large caliber through a tracheostomy Unless the patient requires an artificial airway for swallowing impairment it seems injudicious to subject him to a traumatic surgical procedure for artificial respiration alone when the tank respirator will suffice

SIGNS OF RESPIRATORY INSUFFICIENCY

CAUSES OF INSUFFICIENCY

Decreasing respiratory muscle effort from paralysis
Ineffective respiratory muscle activity as a result of
- Airway obstruction accompanying swallowing impairment
- Shallow irregular respiration occasional gasps and apneic periods observed in encephalitic patients
- Voluntarily inhibited irregular and shallow respirations which occur with untreated swallowing impairment

GENERAL SIGNS

Increasing respiratory rate or irregularity
Decreasing respiratory depth or irregularity
Increasing pulse rate
Poor tolerance to examination and nursing procedures
Fatigue slight pallor
Sleeplessness and restlessness
Occasionally slight to moderate increase in blood pressure
Flaring of nostrils
Breathlessness or dyspnea
Inability or disinclination to take a deep breath on a command
Shortened duration of speech weak cry
Use of accessory muscles (uncommon until late)

Impaired respiration is the most important disturbance in severe poliomyelitis It appears that "insufficiency" refers broadly to a series of events beginning with excessive and inefficient respiratory work, and ending with a biochemical compromise in which respiration does not satisfy the requirements of vital tissues for oxygen uptake and carbon dioxide elimination recognized as asphyxia The point at which a condition such as respiratory muscle paralysis produces insufficiency and then insufficiency progresses to asphyxia is not clear However clinical signs and symptoms which poorly distinguish cause and effect are still useful if they anticipate serious events

Under ventilation from prolonged inhibited irregular and shallow respirations accompanying untreated swallowing impairment should be corrected once a free airway has been assured Dyspnea is rarely observed prior to aspiration and obstruction It occurs only in the patient with intact respiratory muscles Similarly under ventilation usually accompanies the grossly irregular shallow waxing and waning breathing with apneic inter

vals characteristic of brainstem impairment due to any cause Irregular respiration is not a contraindication for artificial respiration but rather an indication

In many instances correction of airway obstruction permits spontaneous respiration to become effective and mechanical assistance is necessary only if respiratory muscles are paralyzed or if asphyxia has already developed

Early elective artificial respiration benefits the patient It has not been difficult to discontinue in the few patients (such as those with encephalitic and regulatory disturbances) who need it for several days to a week or in those who do not develop extensive respiratory muscle paralysis

SIGNS OF ASPHYXIA

Circumoral pallor constricted pupils
Poor skin color and circulation (mottling of the skin)
Profuse sweating especially on the forehead
Deterioration of well being and responsiveness
Progressive restlessness inability to sleep Apprehension ultimately leading to a panic state
Confusion delirium
Marked dilation of nostrils often with frank dyspnea
Thready pulse occasionally hypertension followed by hypotension

LATE

Gasping respiration alternating with feeble respiratory movements and prolonged apneic intervals
Appearance of facial components of breathing twitching around mouth
Intermittent cyanosis hallucinations panic coma persistent cyanosis death

Asphyxia should be regarded as a complete failure of the breathing mechanism The extent to which biochemical alterations of oxygen carbon dioxide and hydrogen ion concentration are responsible for these signs is not known It is clear that biochemical equilibrium is maintained for a surprising period in the face of progressive respiratory impairment and therefore alterations of these chemical variables must be considered to be evidence of failure of respiration

From a physiological point of view the respiratory disturbances which can result in asphyxia include mechanical inefficiency of the respiratory muscles muscle fatigue pulmonary under ventilation faulty distribution of air within the lungs inadequate or improper blood distribution to the ventilated lung tissue and impediments to the diffusion of oxygen and carbon dioxide between the alveoli and blood

RULES FOR THE USE OF THE TANK RESPIRATOR

AVOID EMERGENCIES DUE TO EQUIPMENT FAILURES!

PROPER ORIENTATION

All physicians and nurses dealing with respirator patients should experience a trial of artificial respiration in a tank.
All personnel should know how to operate and use respiratory equipment
Practice hand operation
Practice placement of a normal subject in the respirator

PROPER USE

Before use always check operation of motor pressure and rate adjustment and hand operation
Always hand pump while power failure is being corrected (Turn off motor switch first)
Recognize and correct common failures
  Disconnection of power cord at wall outlet and motor
  Leaks around neck collar portholes and intravenous inlets
  Blockage of suction and pressure inlets in tank by linens
  Belt slippage at slow cycling rates

"When considering the use of mechanical aids the patient s possible needs must always be anticipated Every effort should be made to avoid crises and emergencies Equipment should be kept in perfect working order at all times It should be brought close to but out of sight of the patient for whom its use is being considered The location of electrical outlets should be known to the personnel involved Fuses plugs and extension wires should be in good condition "[7]

After the respirator has been turned on and checked the carriage is pulled out and the neck collar is opened fully by tightening the collar straps (Cloth straps may be used to retract the sponge rubber collar if the tank is not equipped with leather straps) The patient should be lifted by two people on the same side carefully supporting his head back, arms and feet The lifters should first slide the patient toward themselves Then lift and roll him against their chests thus bringing his center of gravity closer to theirs This balances the load and makes the patient feel secure

Place the patient on his back on the tank carriage putting his feet in first Slide the patient through the neck opening with one person grasping the bony prominences of the shoulders and the other grasping the bony promi

nences of the hips If the patient s head is large, turn to the side If neck weakness is present a third person needs to receive and control the head Extend the head at the neck thus lowering the nose and chin The patient s body should be placed as far forward as possible with the shoulders against the head end of the tank Adjust the head level Place an extra foam rubber neckpiece (24 inches long 3 inches wide ½ inch thick) folded in a soft cloth (old diaper) around the neck crossing on the upper sternum and loosen collar straps starting with the lower ones Before closing the carriage of the respirator check to see that the patient s extremities are safely placed and that he is comfortable Check the gauge to see if the desired pressure has been obtained

SUPPORTIVE MEASURES FOR THE RESPIRATOR PATIENT

GENERAL

Every effort should be made to prepare the patient psychologically for the acceptance of artificial respiration

A free airway must be assured or obtained

Oral fluids and medications should not be permitted the first 48 to 72 hours in the febrile critical patient otherwise in the first 12 to 24 hours

Gastric and intestinal distention and air swallowing may limit the diaphragmatic excursions produced by artificial respiration Distention is effectively treated by prompt gastric intubation suction and the use of subcutaneous prostigmine *

Measures to insure comfort assume more importance in the respirator patient Discomfort from urinary bladder retention should be avoided

Encourage the patient to swallow and talk during the expiratory cycle of the respirator

The poliomyelitis patient with respiratory difficulty is naturally apprehensive and anxious "The physician must do everything in his power to allay these anxieties He should explain the objective of mechanical therapy stress its beneficial effects its temporary nature and usually successful outcome If patients are nearby who have come through a period of treatment with mechanical aids these patients should be cited as examples Parents should be acquainted with the same factors and their assistance should be employed if it is judged that their influence will be beneficial If it is possible the aid of a psychiatrist should be enlisted"

The actual effectiveness of artificial respiration may depend on the patient s cooperation For this reason psychological acceptance of the respirator is a paramount requirement of artificial respiration The patient must be as comfortable as possible He must learn to set up new patterns of swallowing and glottic coordination for breathing swallowing and speech *The apneic patient is less able to prevent aspiration* of oral secretions or to expel tracheobronchial secretions since he is unable to cough He must

Dosage of prostigmine subcutaneously is from 0.5 cc to 1 0 cc of a 1 1 000 solution depending upon the age This dose may be repeated once in 30 minutes no more often than every 4 hou s Aft r removal of the tube 15 0 mgm by mouth every 6 hours may be beneficial in the adult patient for 2 to 3 days

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depend upon reflex protection of the upper airway by swallowing accumulations of secretions and closure of the glottis to prevent aspiration This is abolished when the patient is comatose or has any swallowing impairment The infant has especially poor reflex protection of the airway and chokes easily

INITIAL ADJUSTMENT OF THE RESPIRATOR

NEVER LEAVE PATIENT UNATTENDED!

SUGGESTED SETTINGS FOR THE TANK RESPIRATOR

Age/yrs	*Rate/min*	*Pressure/cm H_2O*
0 2	30-40	-12
2-5	24-35	-14
5 10	24 28	-15
10-15	20	-15
Adult	16 18	-14 to -18

SUGGESTED TIDAL VENTILATION IN THE TANK RESPIRATOR

Adults	*Rate Range*	*Tidal Volume Male*	*Tidal Volume Female*
Large—200 lbs	20 12	450-650 cc	450-500 cc
Medium—150 lbs	20 12	400-550 cc	300-450 cc
Small—100 lbs	20-12	300-450 cc	250-350 cc.
Children			
Large—80 lbs	24 16	225-250 cc	
Med um—50 lbs	30 20	140 170 cc.	
Small—35 lbs	32-25	100-110 cc	

Appropriate minute volumes are indicated by multiplying rate times tidal volume

Tidal volume measurements are extremely valuable for
- Individualization of respirator settings
- The avoidance of under ventilation and extreme hyperventilation
- The detection of complications

DETERIORATION OF THE PATIENT'S GENERAL CONDITION IS MOST OFTEN THE RESULT OF INADEQUATE PULMONARY VENTILATION

The values for suggested settings of rate and pressure are empirical and are useful as a starting point in individualization Most tank respirators have some positive pressure on expiration even with the positive" exhaust valve fully open Patients usually find positive pressure on expiration in excess of 5 cm of water uncomfortable

Individualization of respirator settings especially the pressure adjustment is greatly simplified by routine measurement of tidal ventilation (amount of air inspired with each cycle of the respirator) The values in the table above have been selected to promote slight hyperventilation which clinically seems to be necessary for most patients in the acute phase

If tidal volumes are measured repeatedly at the same respirator pressure setting and rate decreasing values may indicate the development of airway obstruction pulmonary complications such as atelectasis and pneumonitis and circulatory complications such as cardiac failure and pulmonary con gestion

Consideration should be given to the patient with a tracheotomy since the caliber of the artificial airway is less than the natural one An endotra cheal airway reduces tidal exchange approximately twenty five per cent at the same pressure setting because of increased resistance to airflow

The patient must never be left unattended at the beginning The security which the patient feels when he has another person in the room with him who is trained in the operation of the respirator, allays his anxiety and promotes satisfactory artificial respiration

RATE AND PRESSURE ADJUSTMENT OF THE RESPIRATOR

FACTORS IN RATE ADJUSTMENT

Rate is subjectively more important than pressure for the synchronization of spontaneous breathing with the respirator At first duplicate the spontaneous rate

Assist the patient to synchronize by counting cadence or commanding the patient to breathe in and then out

If the chosen rate is faster than the suggested range in the table it should be decreased just to the point at which the patient begins to introduce spontaneous efforts as a supplement to the respirator rate

If the patient is apneic or comatose use table value and consider the body temperature since rates of breathing are more rapid during the febrile phase If the patient is afebrile the slower rate is usually more applicable

Rapid rate approximating spontaneous rate is essential for the most effective coordination with irregular shallow breathing

FACTORS IN PRESSURE REGULATION

Tidal ventilation should be proved adequate by measurement

Initial pressure values should be altered by measurement and the patient s general response when necessary

Pulmonary or circulatory complications and tracheotomy require higher pressures for adequate depth of breathing

The factors used in rate and pressure adjustment are self explanatory However certain features should be pointed out It is desirable to let the patient determine the most acceptable rate setting of the apparatus and subsequently ventilatory measurements should be used to determine appropriate ranges of tidal volume for the rate which is chosen and for the pressure which will produce it Minute volume of ventilation has not been emphasized for the reason that suggested tidal volumes are paired with rates which will correspond to those found desirable by most patients and yet fall within the limits equal to or slightly exceeding the needs of the uncomplicated patient

Proper rate and pressure adjustments are easier to obtain in the coopera

tive patient who is introduced to artificial respiration while he still has spontaneous breathing ability

In the absence of ventilatory measurements a satisfactory adjustment can be obtained from the table rates and pressures and the development of clinical evidence for satisfactory adjustment of ventilation as outlined on the following page

EVIDENCE OF SATISFACTORY ADJUSTMENT OF THE RESPIRATOR

Disappearance of anxious facial expression restlessness and sleeplessness The patient relaxes and dozes or sleeps
Improvement of the vital signs such as change of pulse rate and blood pressure toward normal
General improvement in sensorium and feeling of well being
Acceptance of the rhythm of the respirator synchronization of spontaneous breathing and then disappearance of spontaneous effort with relaxed dependence upon the respirator
Demonstration of adequate pulmonary ventilation

The physician must steer a course between the serious danger of hypo ventilation and the minor matter of hyperventilation Tidal volumes which appear to be proper for the individual patient may slightly exceed either table values or predicted values based on normal metabolism Errors in ventilation should occur on the side of hyperventilation Nonetheless it is usually possible to avoid extreme hyperventilation

A sleeping patient presents a good opportunity to evaluate respirator adjustment Excessive ventilation may be presumed to occur at the point that glottic closure becomes audible during auscultation of airway sounds at the mouth if the respirator negative pressure is progressively increased On the other hand gradual diminution of the negative pressure may cause 1) dilation of the nostrils 2) restlessness and 3) spontaneous respiratory efforts when under ventilation occurs Between these two points there is proper ventilation Such suggestions are of importance when artificial respi ration is introduced early

Color of the skin of the face and neck may be misleading since venous obstruction of the neck veins by the collar produces cutaneous circulatory stasis suffusion and cyanosis Hyperventilation may also produce a flushed facies On the other hand the color and circulation of the ear which has been vigorously rubbed and therefore arterialized is useful in judging the presence of stasis and cyanosis in the arterial blood Visible cyanosis occurs only when there is 5 7 gms of unsaturated hemoglobin and therefore cya nosis is a treacherous guide to adequate ventilation

COMPLICATING CONDITIONS IN THE USE OF ARTIFICIAL RESPIRATION

IF THE PATIENT NEEDS ARTIFICIAL RESPIRATION PREVENTIVE AND CORRECTIVE MEASURES MUST BE CARRIED OUT SO THAT IT MAY BE SAFELY USED

Swallowing impairment increases the likelihood of pulmonary aspiration and airway obstruction

Upper airway obstruction occurs readily in the supine and comatose or sedated patient with relaxed tongue and epiglottis

Pneumonitis and atelectasis occur more readily in respirator patients

Hypotension may be intensified by a decrease in venous return to the heart during the negative cycle of the tank respirator

Tracheotomy introduces an increased resistance to ventilation and complicates nursing care

Increased insensible body water loss may result from increased pulmonary ventilation and excessive perspiration in the tank patient

Impaired body heat exchange can develop from retardation of skin evaporation and radiation mechanisms

These conditions are not contra indications to artificial respiration Artificial respiration is indicated only for the prevention of respiratory insufficiency when the spontaneous effort is inadequate or tiring If the patient needs respiratory assistance and impediments to its effective use are present they must be corrected The patient s condition should not be aggravated by artificial respiration Thus if airway obstruction has developed it must be corrected for effective ventilation in the respirator

Artificial respiration does not duplicate normal breathing It can produce adequate *pulmonary ventilation* in the uncomplicated situation Alterations of distribution of air in the lungs[8] and blood perfusion can occur and this may account for some of the differences

Atelectasis and pneumonia are special problems in the management of the respirator patient (See Prevention and Treatment of Pulmonary Complications pages 61 and 62)

The respirator during inspiration interferes with the return of venous blood to the heart which is in direct opposition to normal breathing Such circulatory effects may be dangerous in the hypotensive patient or when suitable compensatory responses are lacking

LABORATORY GUIDES TO RESPIRATORY MANAGEMENT

GENERALLY AVAILABLE
Determination of pulmonary ventilation and compartments (See Appendix)

SPECIAL STUDIES
Arterial blood analysis
Oxygen content and per cent hemoglobin saturation CO_2 content and p CO
Ventilatory gas analysis
Expired alveolar" p CO_2 and pO
CO excretion and oxygen uptake

The value of pulmonary ventilatory measurements and vital capacity determinations has been clearly established

Special laboratory studies are not generally available and may be of indeterminate therapeutic value In general chemical determinations do not direct the care of the average respirator patient Arterial values alone unless very abnormal are not particularly helpful In certain instances serious conditions such as arterial hypoxemia or acidosis can be detected only by arterial blood analysis In some severely ill respirator patients arterial hypoxemia has been demonstrated in the presence of low carbon dioxide values which are considered *representative of hyperventilation*[9] *Thus* chemical studies may point out unexpected biochemical disturbances and assist in the evaluation of oxygen therapy and ventilatory adjustments

Preliminary examination of arterial pH and carbon dioxide content has revealed alkaline pH values and low carbon dioxide contents in acutely ill patients with and without respiratory muscle paralysis[10 11 12] Furthermore it may be clinically advisable to provide mechanical respiratory assistance to patients who show chemical evidence of hyperventilation but who are tired and need respiratory rest Carbon dioxide retention has not been a safe guide to respiratory assistance in our experience The reasons have not been unequivocally established but some contributory conditions have been recognized Severe apprehension and central regulatory disturbances can produce hyperventilation excessive carbon dioxide elimination and lowered p CO s may accompany the respiratory adjustment to high oxygen demand hypochloremic alkalosis may occur alterations of renal

electrolyte regulation have been demonstrated and other factors such as tissue metabolism which influence blood gas and hydrogen ion composition may be disturbed In our experience arterial carbon dioxide retention leading to acidosis is usually associated with airway obstruction pulmonary complications in the respiratory patient and excessive unaided breathing time in the convalescent patient with decreased vital capacity

It should be noted that venous blood determinations of pH and CO_2 may be misleading in respiratory management since they do not directly reflect respiratory function as does the arterial blood (See pages 63 and 64)

Arterial oxygen saturation is preserved over a wide range of oxygen content especially in the slightly alkaline arterial blood characteristic of the respiratory patient Its determination is of value only as an indication of complete failure of respiratory function or as a sign of severe pulmonary and circulatory complications which impair oxygen uptake

EARLY INDICATIONS AND TESTS OF SWALLOWING IMPAIRMENT

TESTING THE PATIENT'S SWALLOWING WITH LIQUIDS OR SOLIDS IS DANGEROUS

The patient is the first to note and complain about swallowing difficulty

Frothy secretions accumulate in the pharynx.

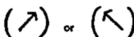
A tongue blade readily provokes an ineffective or incomplete gag reflex or incoordinate gagging with choking

Absent or asymmetrical movement of the posterior pharyngeal wall.

NORMAL



ABNORMAL



Absent or asymmetrical opposition of tonsillar pillars

Angle sign—lack of subglossal fullness and contour

NORMAL



ABNORMAL



Weak or absent elevation and descent of hyoid and thyroid cartilage against resistance of finger

Weakness of anterior neck muscles

Fluoroscopic examination can demonstrate impaired swallowing (with soluble bronchographic media)

Patient hacks spits and drools prefers to sit up and may be afraid of recumbency

In most instances swallowing difficulty is a result of involvement of the Xth nerve motor nuclei Swallowing impairment is objective clinically even though swallowing is a complex function which requires extensive brain stem neuro regulatory activity and muscular coordination

Palatal paralysis has not been emphasized for several reasons (a) in itself asymmetrical or absent movement of the soft palate and uvula produces nasal voice and nasal regurgitation not swallowing difficulty and

(b) it may occur as an isolated indication of brain stem involvement or be associated with facial paralysis and no swallowing impairment or other evidence of severe illness It remains only as an important sign of extension or localization of the disease to the brain stem (bulbar poliomyelitis)

In any case of suspected swallowing difficulty no fluids or solids should be permitted by mouth

IMMEDIATE MEASURES IN THE TREATMENT OF IMPAIRED SWALLOWING

REMOVE SECRETIONS AND PREVENT THEIR ACCUMULATION

Immediately position the patient prone or side lying

Raise the foot of the bed 10°

Use intermittent suction with a smooth end multiple perforated rubber catheter attached to the suction machine through a Y tube for finger control of suction whenever secretions accumulate Suction pressure should be at least 5 inches of mercury and no more than 15 inches of mercury *

Avoid gagging choking and injury to the pharyngeal mucosa from excessive suctioning or high pressure

Let the cooperative patient suction himself

Check effectiveness of suction repeatedly to determine how often suction is actually necessary

ELIMINATE NEED TO SWALLOW

No oral feedings fluids or medications

Give parenteral fluids

Use small naso-gastric indwelling polyethylene tube for drip feeding if patient s course is uncomplicated even in the febrile period

Check position of tube to avoid placement in the duodenum

Minimize gastro-intestinal distention by avoidance of large volume feedings and excessive fat content.

Begin gavage feedings with the patient s shoulders higher than the stomach to minimize regurgitation

Most suction machine gauges are calib ated in inches of mercury over a range from 0 25 Maximum suction is usually obtainable only if the suction tube is completely obstructed since the volume of air movement of such systems is quite small and a leak (open catheter) quickly reduces the suction pressure Motor operated devices are not suitable for continuous suction, and can be dangerous because high pressures will be developed when mucosal tissues block the suctioning catheter and tissue trauma with hemorrhage and avulsion may result Low suction devices (thermotic pumps) producing 5-8 inches of mercury (100-150 mm Hg) can be used continuously Water turbine types of central suction which do not exceed 8 inches of mercury and can maintain such pressures with a full leak (complet ly unblocked catheter) are suitabl for continuous suction if used with a multiple perforated catheter However drying of mucosal surfaces and robbery of the inspiratory effort may occur with the use of such continuous high volume devices

An inexpensive laboratory suction faucet attachment, operated by water pressure, is also a satisfactory aspirating device but it is capable of high vacuum trauma. Intermittent and skillful suction by an attentive staff and patient appears to be best.

The prevention of under ventilation and asphyxia is the objective of treatment no matter what methods are employed These serious and fatal complications appear to be a result of upper airway obstruction aspiration lower airway obstruction and irregular shallow breathing efforts

The nutritional handicap resulting from inability to swallow can be readily corrected through parenteral routes and by nasogastric tube feeding On the other hand liability to other hazards of swallowing is still present because of the large volume of oropharyngeal and tracheobronchial secretions *Prevention of under ventilation and asphyxia challenges all of the judgment skill, experience and resourcefulness of the physician*

EVIDENCE OF PROGRESSIVE SWALLOWING IMPAIRMENT

THE INFANT AND YOUNG CHILD WITH SWALLOWING IMPAIRMENT MAY ASPIRATE FATALLY AT ANY TIME

SPECIFIC SIGNS

- Increasing production of secretions and accumulation of secretions in the oropharynx
- Shallow, and often irregular respirations which improve after suction
- Inspiratory stridor if vocal cord paralysis develops
- Coarse rhonchi and roughness in the oral air stream detected by auscultation of the mouth and neck with a bell type stethoscope
- Rising pulse rate and blood pressure occur frequently but not invariably
- Deterioration of general condition lack of concern over inability to swallow circumoral pallor sweating

LATE SIGNS

- Choking and cyanotic episodes
- Labored respirations dyspnea and obstructed breathing may occur after aspiration Exhaustion a state of semiconsciousness or respiratory muscle paralysis prevent the development of these signs of aspiration
- Signs of asphyxia (See page 21)

Prompt recognition and treatment of swallowing difficulty is essential to prevent a) upper airway obstruction b) tracheobronchial aspiration and lower airway obstruction c) underventilation resulting from shallow inhibited and irregular respiratory efforts and d) choking with glottic spasm and prompt asphyxia and death Swallowing impairment is a serious development in the course of the disease because it may be accompanied by fatal disturbances of brain stem control of respiration and circulation

Fluoroscopic evaluation of swallowing has been especially useful because it objectively demonstrates the swallowing effort. This procedure identifies the extent of paralysis the degree of incoordinate and incomplete swallowing, and the presence of a hazard of laryngeal and tracheal aspiration early

in the course of swallowing difficulty Prior to any such test of swallowing the pharynx should be carefully examined to determine if any accumulation of secretions has occurred and if so they should be removed by careful suctioning Then, one teaspoonful of a diluted water soluble bronchographic medium such as Dionosil® is held in the patient s mouth and then swallowed during fluoroscopic examination Slight aspiration of the bronchographic material does not seem to be harmful if it occurs in the cooperative child or young adult Otherwise no attempt should be made to test swallowing with other fluids Failure to remove secretions which may be present in the throat however can produce a choking spell and lead to glottic spasm Choking and careless manipulation of the suction tube stimulates an increased production of tracheobronchial mucous secretion

® Dionosil is the brand name for propyliodone aqueous suspension from Glaxo Laboratories, Ltd. Greenford England Available from Picker X ray Corporation 25 South Broadway White Plains N Y

INDICATIONS FOR IMMEDIATE TRACHEOTOMY

TRACHEOTOMY IS NECESSARY

TO PERMIT EFFECTIVE ARTIFICIAL RESPIRATION WHEN THERE IS

Any impairment of swallowing combined with respiratory muscle paralysis requiring artificial respiration

The need for artificial respiration in the disoriented confused stuporous or comatose patient who has ineffective reflex protection of the upper airway The heavily sedated patient requiring artificial respiration is particularly susceptible to sudden obstruction

TO PREVENT UNDERVENTILATION AND AIRWAY OBSTRUCTION WHEN THERE IS

Severe swallowing impairment or when conservative measures do not prevent accumulation of oral secretions in any patient with swallowing difficulty

The everpresent hazard of aspiration during and after feeding in the infant respirator patient

Rapid progression of swallowing impairment or respiratory insufficiency and in addition any evidence of central respiratory and circulatory disturbances heralding fatal disease

EVERY ASPHYXIATED PATIENT REQUIRES AN AIRWAY TO PERMIT EFFECTIVE RESUSCITATION

The effective employment of a tracheotomy to preserve and protect the airway depends upon anticipatory judgment Just as the respirator is used to prevent the development of asphyxia from incipient failure of breathing tracheotomy is used to prevent choking aspiration and airway obstruction from failure of swallowing Fewer patients with swallowing impairment alone require a tracheotomy than patients who have respiratory muscle paralysis require a respirator The decision regarding tracheotomy then is more difficult and involves the determination of the likelihood of airway obstruction and underventilation in a given patient Clinical judgment should take into account a) the effectiveness of conservative treatment b) the ineffectiveness of protective reflexes and coughing to clear the throat and remove tracheobronchial secretions c) the liability of treatment meth

ods to produce exhaustion and fatigue with interference of sleep and rest, and d) the overburdening of personnel and treatment facilities in the pursuit of continuous conservative management of several patients with swallowing difficulty Choking spells and cyanotic episodes indicate that the disease has been permitted to progress too far or treatment has been inadequate and tracheotomy has been delayed too long

In one period of study 47 out of 82 patients with swallowing impairment due to paralysis of the pharyngeal constrictors required a tracheotomy However 25 of these tracheotomized patients either had or developed respiratory insufficiency from respiratory muscle paralysis and also had to have a tracheotomy to preserve the airway and permit effective artificial respiration [18] This situation demanded immediate tracheotomy

Not infrequently the likelihood of progressive respiratory muscle paralysis in association with swallowing difficulty can be anticipated Earlier and less hazardous tracheotomy can be elected before the use of artificial respiration

Tracheotomy should be performed skillfully under local anaesthesia high (using a vertical midline skin incision at the first or second tracheal ring) and with dispatch A high tracheotomy makes proper adjustment of a respirator collar possible should artificial respiration become necessary In general tracheotomy should be performed only after an emergency airway has been established by endotracheal intubation or bronchoscopy This is extremely important for a safe tracheotomy in children and occasionally in the adult patient who has been compromised by progression of the disease to respiratory insufficiency aspiration or obstruction

Artificial respiration must be continued in the respirator patient during the tracheotomy procedure An anesthesia bag mechanical positive pressure resuscitative device or a chest abdomen cuirass respirator may be used to ventilate the patient Oxygen should also be administered during the procedure and should be adequately humidified Oxygen can be administered directly to the bronchoscope or endotracheal airway provided there is no obstruction to the expiratory effort

A well trained team is essential for the safe employment of tracheotomy in the usual epidemic situation It is helpful to have a pediatrician or internist otolaryngologist and anaesthetist on this team as well as a skillful nurse

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See Appendix for suggested equipment for tracheotomy and bronchoscopy

ADVANTAGES AND DISADVANTAGES OF TRACHEOTOMY

ADVANTAGES

- Provides an airway bypassing the glottis
- Acts as a barrier to upper airway secretions
- Facilitates less traumatic repeated bronchoscopy

DISADVANTAGES

- It is an airway of smaller caliber than the trachea
- Involves a traumatic surgical procedure in an ill patient with possibility of surgical complications such as bleeding and (rarely) pneumomediastinum
- Acts as a foreign body and may potentiate mucous production and increase likelihood of infection.
- The tracheal mucosa is exposed to drying and conditions which may injure the ciliary mechanism

The use of a tracheotomy introduces special problems such as (a) protection of tracheobronchial mucosa against drying and infection (b) need for careful collar positioning in the respirator patient to prevent mechanical tracheal erosion (c) necessity of respiratory compensation for decreased caliber of the airway and decreased respiratory dead space and (d) liability of addiction to the abnormal airway especially in younger children and infants

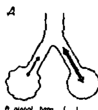
Adequate humidification and temperature control of the inspired air or air oxygen mixtures must be attempted Delivery of the gas mixture to the tube must not obstruct it and there should be no expiratory resistance An open system for delivery of humidified air-oxygen mixtures appears to be the most effective and least dangerous NEVER place an oxygen delivery tube into the tracheal cannula (See pages 46 through 50)

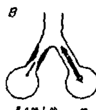
Skillful suctioning should be performed only when necessary Prevent obstruction of the inner cannula as a result of the accretion of secretions Impaired ventilation and bronchial obstruction leading to atelectasis are often a consequence of (a) partial obstruction of the cannula (b) inadequate removal of accumulated secretions and (c) formation of thick viscid secretions as a result of dehydration Any deterioration of the patient s condition demands prompt investigation and elimination of these contributory conditions (See Nursing Care of the Tracheotomy page 87)

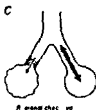
CAUSES OF HYPOXIA AND INDICATIONS FOR OXYGEN THERAPY

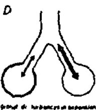
OXYGEN ADMINISTRATION IS NEVER A SUBSTITUTE FOR PULMONARY VENTILATION

Insufficient oxygen intake may result from
- Underventilation in any patient
- Improper adjustment of ventilation in respirator patients who have
  - *Increased oxygen utilization from fever and infection*
  - Decreased distensibility of the lungs due to decreased elasticity or increased resistance to air inflow and outflow
- Uneven pulmonary ventilation









- Abnormal or insufficient pulmonary circulation as a result of myocardial insufficiency and redistribution of blood flow in unevenly ventilated lungs or accompanying circulatory failure
- An alveolar barrier to oxygen diffusion into the blood in pulmonary edema and diffuse pneumonitis

Illustrations used are from *The Lung* 1955 (page 57) by Dr Julius H Comroe Jr *et al* and published by The Year Book Publishers Inc. They are used with the permission of the author and the publisher

CAUSES OF HYPOXIA AND INDICATIONS FOR OXYGEN THERAPY

Oxygen therapy is indicated
- In respirator patients
  - When any sign of respiratory insufficiency or asphyxia develops in spite of ventilation which equals or even slightly exceeds "predicted" values
  - When minimum predicted ventilation cannot be obtained by any adjustment of respirator pressure and rate This situation usually indicates development of serious pulmonary and circulatory complications
  - Whenever pulmonary or circulatory complications are detected
- In any patient when unavoidable or undetected underventilation leading to hypoxia or oxygen debt is suspected clinically from early signs of asphyxia or demonstrated by high minute oxygen consumption (400 to 1 000 cc per minute)

A variety of conditions make the poliomyelitis patient particularly prone to underventilation and uneven pulmonary ventilation Most of the conditions described above can occur in the course of severe disease Tracheobronchial obstruction pulmonary and circulatory complications are the most frequent offenders after respiratory muscle paralysis Another factor which may be of great importance in this situation is the tendency of artificial respiration to promote overventilation in some areas of the lung and underventilation elsewhere [14] Uneven ventilation may then be aggravated during artificial respiration when other provocative conditions are present

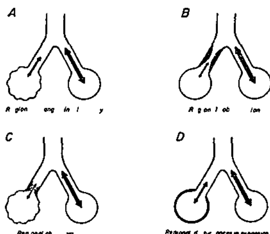
In general artificial lung ventilation which equals or slightly exceeds "normal" predicted values (based on undisturbed metabolism in healthy individuals) will meet the patient s oxygen needs and eliminate the carbon dioxide accumulating from metabolic processes Similarly adjustments of ventilation during illness to meet the increased metabolic demand for oxygen occasioned by fever and nutritional disturbances usually will permit normal oxygenation at levels which preserve the arterial carbon dioxide concentration in the normal range On the other hand underventilation readily produces both hypoxia and carbon dioxide retention

CAUSES OF HYPOXIA AND INDICATIONS FOR OXYGEN THERAPY

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METHODS FOR THE ADMINISTRATION OF HUMIDIFIED OXYGEN OR AIR

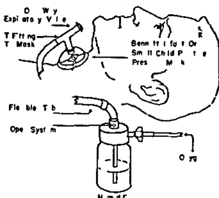
OPEN SYSTEMS for tracheotomized or non tracheotomized patients

Use a small plastic oxygen tent or hood over the head and chest of the bed patient or attached to the head end of the respirator if such is used Provide humidification with at least two nebulizing or mist devices * A close fit of the collar with minimal inward leak is necessary with use of the respirator

SEMI CLOSED SYSTEMS for tracheotomized patients

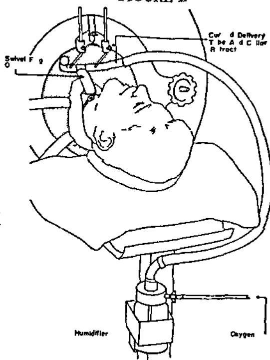
Deliver humidified oxygen from a humidifier through a large bore connecting tube which acts as an inspiratory reservoir Fit the connecting tube to a small breathing mask which overlies and surrounds but does not touch the tracheotomy tube Provide a one way expiratory valve and make sure the humidifier is partially open so that inspiratory obstruction cannot develop ** FIGURE A

FIGURE A



Semi-closed system for the non respirator or respirator tracheotomized patient requiring high oxygen concentrations

FIGURE B



The satisfactory state of affairs in which proper adjustment of ventilation promotes adequate oxygen uptake and appropriate carbon dioxide elimination may disappear with the development of complicating conditions such as decreased distensibility of the lungs, uneven ventilation and disturbances of pulmonary circulation Oxygen uptake may then be impeded to a greater degree than carbon dioxide excretion and hypoxia may develop with great rapidity Furthermore in some seriously ill respirator patients hypoxia indicated by arterial oxygen unsaturation has been observed at levels of pulmonary ventilation which suggest hyperventilation since the arterial carbon dioxide concentration is low and the arterial pH alkaline[15] This dissociation of respiratory oxygen and carbon dioxide regulation from the metabolic demand for oxygen uptake and carbon dioxide elimination may be a direct result of uneven ventilation and faulty blood perfusion in the lungs For such reasons the assessment of oxygen uptake and carbon dioxide elimination has not been sufficiently well elucidated to modify the general and somewhat empirical indications for oxygen therapy indicated in the box above In the absence of ventilatory and arterial gas and pH studies the beneficial effect of oxygen therapy under the circumstances outlined is sufficient indication for its need

In several respects underventilation stands as a separate problem particularly when it occurs during the course of spontaneous respiration Unfortunately oxygen therapy has been widely used as a panacea for insufficient pulmonary aeration In some instances the use of a higher concentration of oxygen in the inspired air may actually further depress spontaneous breathing so that carbon dioxide retention results and respiratory acidosis is allowed to develop[16]

Underventilation presents the same hazards in the respirator patient as in the non respirator patient and this condition must be corrected immediately since it is poorly tolerated by the patient

The ordinary basal metabolism machine or any closed circuit spirometer containing 100% oxygen may point up the need for therapy in the complicated situation Any demonstration of very high minute oxygen consumptions (400 1 000 cc per minute) is simple and presumptive evidence of either increased oxygen demand or oxygen debt These conditions will reveal themselves only if severe underventilation has not occurred since very shallow respiratory efforts may not permit the necessary alveolar ventilation required for oxygen uptake At the very least such measurements may establish unsuspected underventilation and therefore are quite useful

METHODS FOR THE ADMINISTRATION OF HUMIDIFIED OXYGEN OR AIR

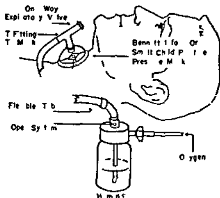
OPEN SYSTEMS for tracheotomized or non tracheotomized patients

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SEMI CLOSED SYSTEMS for tracheotomized patients

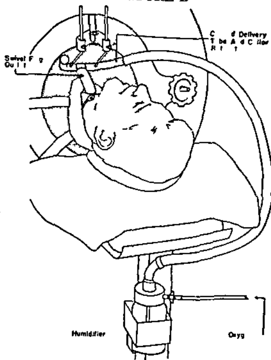
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FIGURE A



Semi-closed system for the non respirator or respirator tracheotomized patient requiring high oxygen concentrations

FIGURE B



METHODS FOR THE ADMINISTRATION OF HUMIDIFIED OXYGEN OR AIR

Utilize a curved delivery tube and collar retractor with a swiveled mist outlet directly over the tracheotomy tube in tank respirator patients ** Attempt to fit the swivel outlet as close to the tracheotomy inlet as possible without directly attaching it to the tube FIGURE B

CLOSED SYSTEMS are particularly useful in very critical patients for brief periods in which a high oxygen concentration must be delivered with large inspiratory pressures Closed systems utilize supplemental positive pressure breathing equipment with demand delivery on inspiration through a mask or tracheotomy to which a humidification or nebulization device is attached *** Some risk of tracheal and bronchial irritation from drying and high oxygen concentration must be taken

During the acute and critical stages of severe disease humidification is essential with a tracheotomy Later on in convalescence this is less important except in dry climates In this situation simple room humidification may be practical ****

Any time oxygen is deemed unnecessary compressed air in cylinders or from special motor driven compressors may be used to operate humidifying equipment

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Nebulizing and fogging devices are available from the following manufacturers

1 NCG Microfier is manufactured and made available by The National Cylinder Gas Company 840 N Michigan Avenue Chicago Illinois (Regional offices in principal cities)
2 NCG Open Top Humidity Tent for use on respirator Same source as above
3 Mist O Gen Humidifier available from Mist O Gen Equipment Division 27 Adeline Street Oakland 7 California
4 Croupette Tent (special tent with *two* nebulizers) available from Air Shields Inc Hatboro Penna

Special humidifiers for closed or semi-closed operation as described above

1 Mistafog Humidifier and Retracto Tube for tank respirator available from the John Bunn Corporation 163 Ashland Avenue Buffalo 2 New York
2 Emerson Tracheotomy Humid fier available from the J H Emerson Company 22 Cottage Park Avenue Cambridge 40 Mass

* For positive pressure respirators and equipment See page 80 footnote

Walton Room Humidifier available from Walton Laboratories Inc Irvington New Jersey

SIGNS OF CENTRAL DISTURBANCE OF RESPIRATORY REGULATION

Irregular—rapid—shallow—incoordinate respirations
Occasional deep breaths followed by apneic intervals
Clustering of respiratory effort or frank Cheyne Stokes waxing and waning patterns
Frequently observed in the patient with either

USUALLY NOT FATAL	"Polio encephalitis"—disturbances in state of consciousness—involuntary motor activity with twitches—muscular jerks—reflex hyper irritability and abnormal reflexes—potentiated during restless sleep
OFTEN FATAL	Severe bulbar poliomyelitis—heralded by swallowing impairment Fatal circulatory and cardio regulatory disturbances may occur concomitantly (In bulbo spinal polio extensive muscle paralysis may preclude evidence of respiratory irregularity) There may be sialorrhea gastric dilatation ileus gastric ulceration and hemorrhage

Central respiratory irregularity in the course of poliomyelitis can be indicative of a number of conditions Similar patterns of abnormal breathing may be the end result of biochemical alterations as well as neurologic disturbances of the central regulatory mechanism The neurologic disturbances may be only transitory or irreversible if extensive viral destruction of the brain stem has occurred This may account in part for the spontaneous recovery of normal breathing in some patients or fatal outcome because of associated and parallel circulatory and autonomic disturbances in others This attractive hypothesis for the varied respiratory and circulatory disturbances in human bulbar poliomyelitis is suggested by analysis of the regulatory function of the brain stem by means of experimental ablation stimulation of discrete areas and pharmacologic dissection in experimental animals Fortunately they are the least common complications of the severe form of the disease

TREATMENT OF CENTRAL DISTURBANCES OF RESPIRATORY REGULATION

No treatment is necessary for mild irregularity which is easily replaced by voluntary commands to breathe regularly This condition may disappear spontaneously

If irregularity persists and unfavorable changes in vital signs develop ventilatory measurements will usually verify inadequate ventilation hence use

Artificial respiration with a tracheotomy
Humidified oxygen therapy
Sedation with barbiturates or chloral hydrate prescribing minimal dosage for age of patient

(Artificial respiration may be necessary for several days to a week followed by spontaneous recovery)

In association with circulatory and other autonomic disorders the prognosis is poor and the failing heart and circulation must be sustained by pharmacologic measures such as administration *of nor epinephrine intravenously and digitalis preparations* parenterally (See **Circulatory and Other Conditions Requiring Immediate Treatment**)

In the critically ill patient adequate pulmonary ventilation may be *achieved only with artificial respiration Obviously asphyxia inadequate* circulation and severe metabolic and biochemical disturbances may contribute to the poor condition of the patient Correction of conditions such as asphyxia preservation of blood pressure and maintenance of fluid and electrolyte balance are important supportive measures in the desperate situation although frequently they will not be effective enough to prevent death due to profound hypotension cardiac failure or arrest pulmonary edema massive gastro intestinal hemorrhage renal failure etc

In the absence of cardiovascular and other autonomic disturbances serious threat to life may not develop and an excellent recovery may be observed

CADIOVASCULAR AND AUTONOMIC ABNORMALITIES OF MAJOR IMPORTANCE

SEVERE HYPERTENSION
SYSTOLIC PRESSURE MORE THAN { 200 mm Hg—Adult. / 160 mm Hg—Child

Pulse pressure is variable from high to low

BRADYCARDIA

Usually of brief duration

HYPERTHERMIA AND SEVERE CUTANEOUS VASOCONSTRICTION

Body temperature in excess of 106° F may occur with cold mottled and pale skin which is clammy to the touch Skin circulation is sluggish and color cyanotic

SEVERE HYPOTENSION
SYSTOLIC PRESSURE LESS THAN { 90 mm Hg—Febrile Adult / 60 mm Hg—Febrile Child.

EXTREME TACHYCARDIA LEADING TO OUTPUT FAILURE—PULSE OVER { 180/min—Adult / 210/min—Child

VENTRICULAR PREMATURE BEATS

Especially in a series

PULMONARY CONGESTION AND EDEMA

Suggested by x ray signs of marked increase in hilar and lung markings and by characteristic QRS vector clockwise dis placement and high peaked P waves with right axis deviation of P vector Edema produces acute respiratory distress and abundant frothy blood tinged secretions

MYOCARDIAL FAILURE AND MYOCARDITIS

Soft and poor heart sounds with progressive enlargement ECG alterations

EMBRYOCARDIA

(170 180) fast unmodifiable and regular heart rate which is usually terminal

SEVERE GASTROINTESTINAL DISTENSION—ILEUS

Hemorrhage ulceration in stomach and small intestines per foration

Fatal bulbar poliomyelitis is often associated with progressive elevation of body temperature to intolerable levels circulatory disturbances such as hypertension and bradycardia followed by tachycardia and fatal hypotension or pulmonary edema Often swallowing impairment heralds such brain stem or "bulbar disease The various disturbances are intermingled and each can lead to a vicious circle of failure of respiration circulation and profound metabolic derangements of body cells in the agonal stage Circulatory and respiratory treatment measures should be employed even though the course of the disease may not be altered

These signs and symptoms may be produced by a variety of conditions virus invasion with involvement of the hypothalmus and the entire brain stem especially the reticular substance [17] altered brain stem function as a result of nervous or chemical disturbances cellular changes in chemical *equilibria of oxygen carbon dioxide and hydrogen ion concentration* specific damage to the cardiac muscles etc Over compensatory or harmful body responses resulting from the stress of disease or treatment procedures may complicate the situation It is usually not possible to separate causes It is more important to prevent or eliminate conditions such as asphyxia which may produce failure of circulation and respiration

CIRCULATORY AND OTHER CONDITIONS REQUIRING IMMEDIATE TREATMENT

HYPERTHERMIA Vigorous cooling of the body should be attempted to prevent elevation of the body temperature to levels exceeding 104° (rectal) High body temperatures in poliomyelitis patients are usually accompanied by cool mottled skin which suggests decreased skin circulation and de creased heat loss Measures should be used which will increase the heat loss from the body through cutaneous vaso-dilation and increased sweating Alternate applications of warm and cool wet sheets to the entire body may be useful if there is a good circulation of air over the patient Chilling applications such as alcohol and ice appear to produce extreme vaso constriction and actually impede heat loss unless ice packing is used long enough to induce hypothermia Brushing of the skin with a surgical scrub brush improves skin circulation

The use of 5% alcohol solutions in 5% dextrose intravenously seems to be a valuable adjunct Rarely more than 200 cc to 1 000 cc. of such solutions are necessary in any 12 hour period

Aspirin has not been especially valuable in the management of extreme hyperthermia The duration of the action of aspirin is very short and un certain so that its effectiveness is limited It may mask the progressively elevated body temperature observed in advancing central involvement.

HYPERTENSION Systolic blood pressure levels exceeding 200 mm of mercury in the adult and 160 mm of mercury in the child may respond to the parenteral administration of Serpasil® The maximum dosage is 80 125 micrograms per kilogram of body weight per 24 hours One fourth is admin istered as a stat dose either intramuscularly or intravenously for rapid effect (30 to 120 minutes) This dosage may be repeated once in 2 hours if needed Proper response is usually indicated by decreasing blood pressure marked flushing of the skin and a red suffusion of the face and conjunctiva The remainder of the 24 hour dose is given in 6 to 8 hours and it is rarely needed for more than 24 hours Hypertension is usually a transitory condi tion followed by hypotension and often precedes or indicates the develop ment of asphyxia or extension of the disease process to the brain stem For this reason a hypotensive drug is used which will not block the patient s response to vaso pressors should their use become necessary Ganglionic blocking agents such as the hydralazine derivatives and hexamethonium chloride compounds are therefore contraindicated in the management of this variety of acute hypertension If hypertension persists it should be treated to prevent encephalopathy and cardiac failure

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® Serpasil is the proprietary name of an extract of Rauwolfia serpentina (injectable solution) made available by Ciba Pharm ceutical Products Inc Summit N J

HYPOTENSION AND CIRCULATORY FAILURE This condition is usually effectively corrected with the continuous drip intravenous administration of a solution containing 4 mgm of Levofed® to 1 000 cc of 5 or 10 per cent invert sugar in water The rate of administration is entirely dependent upon the response of the blood pressure which must be measured at frequent intervals (5 to 10 minutes) at first and later at 30 minute intervals after a proper rate has been established In some instances the use of Levofed may be necessary for several days or even several weeks The use is tapered off gradually by alternating periods of several hours without the drug Hypotension must be corrected immediately in order to preserve vital central nervous system function and renal activity Great care should be exercised to prevent extravasation of the vaso pressor solution since necrosis of tissues may result In general such critically ill patients who require vaso pressors to sustain blood pressure should have a vene section (cut down) with either an indwelling polyethylene plastic catheter or a cut down cannula in place since fluid administration and regulation must be continuous and accurate The hypotension accompanying the circulatory effect of artificial respiration in patients with faulty circulatory regulation may be effectively treated with Levofed Pressure adjustments of the respirator by altering negative inspiratory pressure and positive expiratory pressure to equal values such as −10 cm to +10 cm of water may be useful. The lowest negative pressure should be used which achieves minimum safe ventilation as indicated on page 29 to minimize the circulatory effect of the respirator

CARDIOREGULATORY DISTURBANCES Bradycardia is the most dramatic regulatory disturbance and is often only a transitory and self limited episode For this reason drug treatment is usually unnecessary However if bradycardia is associated with other evidence of excessive parasympathetic activity such as gastro intestinal bleeding Banthine® may be useful This is the most effective parasympathetic blocking agent for this condition A stat dose of Banthine is administered intravenously in a dosage of 5 to 10 mgm slowly injected Parenteral Banthine solution should not exceed a concentration of 5 mgm per cc The peripheral and apical pulse should be observed during its administration The parenteral dose can be repeated in 30 minutes if the bradycardia rhythm does not revert With the development of gastro intestinal bleeding gastric intubation is advisable and Banthine may be given through the gastric tube in an oral dose of 25 to 50 mgm every 6 hours for 48 to 72 hours Atropine is contra indicated and tends to thicken secretions

® Levofed is the proprietary name of levarterenol bitartrate (injectable solution) made available in 4 mgm ampoules by Winthrop Stearns Inc New York 18 N Y

® Banthine is the proprietary name of methantheline bromide in 50 mgm ampoules made available by Searle Chicago Illinois

Gastro-intestinal bleeding may be extensive and blood replacement necessary if the hemoglobin and hematocrit values indicate blood loss Rapid thready pulse thirst and ashen gray shock may be observed with extensive blood loss If this situation occurs immediate transfusion is indicated In general transfusion is necessary only for blood loss in acute poliomyelitis and its use should be avoided in the management of hypotension of central origin which responds so well to vaso-pressors Circulatory over loading cardiac failure and pulmonary edema are aggravated by transfusion

ASPHYXIA The asphyxiated patient may present bradycardia and hypertension at first followed by hypotension in a few hours The treatment is identical to that recommended before but adequate pulmonary ventilation must be established Bronchiolar constriction appears to accompany hypoxemia and the asphyxial state and must be corrected Ephederine sulfate appears to be beneficial when administered subcutaneously or intramuscularly in a dosage of 5 0 to 25 mgm depending on the age In a desperate situation the cautious use of aminophylline (1 gm to 5 gm in 5 to 50 cc of 50% glucose solution) intravenously may be helpful Maintenance doses of parenteral ephedrine every 4 to 6 hours may be necessary for 24 to 48 hours The oxygen content of the inspired air should be at least 40% and the use of an intermittent positive pressure device to administer oxygen either alone or in conjunction with the tank respirator may be life saving

MYOCARDIAL INSUFFICIENCY AND MYOCARDITIS Impairment of cardiac function occurs frequently in severe poliomyelitis The pathogenesis of these conditions may not be clear because so many contributory events accompany severe disease Thus central nervous system cardio-regulatory disturbances conduction defects metabolic disturbances and mechanical conditions all embarrass myocardial function The myocardium may suffer from metabolic derangements such as hypokalemia hypercalcemia and hypoxemia prolonged hypotension or small pulse pressures Actual viral invasion of myocardial tissue has been demonstrated but the frequency of this inflammatory condition has not been clearly established Valuable indicators of disturbed cardiac function are the quality of the heart sounds and the electrocardiogram either empirically or as registrations of regulatory and conduction disturbances Even though the ECG is incapable of identifying conditions which produce common electrical effects such as prolonged Q–T time flattening or inversion of the T wave pronounced clockwise QRS vector shifts and marked separation of the QRS and T vectors still it is the most direct indicator for determining the need for digitalization and the response to digitalization

These conditions are best treated with digitalis preparations A purified digitalis preparation for parenteral administration is preferred and conventional dosage should be employed with caution since some poliomyelitis patients with myocardial involvement appear to be sensitive to digitalis

action Dosage for digitalization is usually from 025 mgm to 010 mgm. (10 to 25 micrograms) per kilogram of body weight depending on the age The higher dosages are used in children and the smaller dosages in adults A test for hypersensitivity to digitalis effect can be carried out by administering one tenth of the total digitalizing dose intramuscularly and performing an electrocardiogram in 4 to 6 hours Hypersensitivity is often indicated by the development of escape beats or conduction disturbances If these conditions are not detected after the test dose or they have occurred prior to the administration of digitalis one half of the total dose may then be administered intramuscularly and the remainder in divided doses at 6 to 8 hour intervals Check for digitalis effect by electrocardiographic examination between each dose A decrease in tachycardia may be considered a favorable early effect The quality of the heart sounds may also be noted to improve Maintenance doses appear to be within the range of 5 to 10 per cent of the total digitalizing dose and are rarely necessary for longer than 7 to 14 days As digitalis is usually utilized as an anticipatory measure intravenous administration has not been necessary In the presence of markedly elevated body temperature a favorable digitalis effect may require larger doses than suggested here but not in excess of one and one half times the recommended full digitalizing dose

It is also important to avoid rapid administration and large volumes of intravenous fluids Continuous administration of fluids at minimal rates is best

PULMONARY EDEMA This condition has been uncommon Avoiding the use of plasma plasma expanders and whole blood may be important factors in minimizing pulmonary edema If pulmonary edema occurs the contributory cardiac failure may be indicated in the electrocardiogram with the evolution of high peaked P waves in the standard limb leads and the development of right heart axis deviation or clockwise QRS vector shifts During an episode of pulmonary edema pulmonary ventilation is acutely disturbed and intermittent positive pressure breathing with some expiratory resistance may be helpful The slow intravenous administration of aminophylline in a dosage range of 1 gm to 5 gm in 5 to 50 cc of 50% glucose solution may be of value when combined with effective ventilation and maintenance of blood pressure Heroic treatment may be completely ineffective

CARDIOVASCULAR ABNORMALITIES OF MINOR SIGNIFICANCE

Arrhythmias pronounced sinus arrhythmia wandering pacemaker
Moderate tachycardia rate less than 150/min in adults 180/min in children
Moderate hypertension systolic and diastolic
Paroxysmal supra ventricular tachycardia of brief duration
ECG abnormalities due to cardiac displacement (abnormal QRS vector in frontal projection elevated S T segment deep Q waves S_1 S_2 S_3 pattern etc)
Right bundle branch block

These should be recognized primarily because no treatment is indicated In addition such findings do not signify a serious prognosis In a number of cases ECG alterations and circulatory findings are suggestive of the type of body stress occasioned by severe illness and are therefore probably not specific Prolonged Q T time and shortened P R intervals are good examples

SIGNS AND SYMPTOMS OF PULMONARY COMPLICATIONS

TRACHEOBRONCHIAL ASPIRATION, ATELECTASIS AND PNEUMONITIS

Deterioration of condition such as poor color, loss of appetite change in mental outlook

Recrudescence of slight fever, frequently polymorphonuclear leukocytosis

Change in vital signs increase in pulse rate increase in blood pressure poor peripheral circulation These may be signs of inadequate ventilation also

Complaint of something in the throat

Detection of accumulated secretions in the throat (Auscultation with a bell stethoscope)

Auscultation of a double expiratory sound with a midpause or click is noted frequently with atelectasis or tracheobronchial obstruction Marked diminution in volume of outflow

Reduction in tidal volume at high inspiratory pressures This reflects a change in the mechanical properties of the lung such as decreased elasticity or increased resistance to air flow

Radiographic changes in lung fields

Aspiration of purulent tracheobronchial secretions

In some instances frank evidence of tracheobronchial aspiration or atelectasis may be present shift of mediastinum displacement of the point of maximum cardiac impulse and other findings suggestive of collapse of a lobe These findings are not uniformly present especially in the respirator patient Pulmonary complications may occur with surprisingly few clinical signs and symptoms so should be anticipated as a common cause of deterioration of the patient s condition or of unexplained fever

PREVENTION OF PULMONARY COMPLICATIONS

PREVENTIVE MEASURES

Prevent bronchial aspiration of secretions by careful oral and tracheal suction whenever secretions accumulate

Frequent change of position Avoid prolonged head down position Alternate the time in the head down and horizontal positions

Insure adequate humidification of inspired air

Attempt to preserve muco ciliary mechanism Prevent tracheal drying and crusting Change tracheotomy tube q 2 days during the acute phase Less often during convalescence

Immediately use artificial cough maneuvers with the vacuum cleaner or the manually assisted cough with any complaint of inability to clear throat or evidence of accumulation of secretions (See Appendix)

Use intermittent deep breath intermittent abdominal splinting to promote thoracic expansion

Obtain serial smears and cultures for determination of predominant organisms in tracheobronchial tree

Preventive measures are extremely important Nevertheless the respiratory poliomyelitis patient has an increased liability to pulmonary complications even under ideal circumstances Causative factors include (a) easy aspiration of contaminated secretions because of absent effective reflex protection of the airway (b) inability to remove secretions loss of coughing ability failure of ciliary mechanism increased amount and viscidity of secretions (c) infrequent maximum lung expansion such as occurs with sighing and exercise and (d) alterations of air distribution in the lungs and changes in pulmonary blood flow as a result of prolonged immobilization in the supine position respiratory muscle paralysis and artificial respiration

In any case the preventive measures should be routinely employed and prompt adequate treatment should be carried out Antibacterial therapy should be directed by the sensitivity of the predominant organism Continuous prophylactic antibiotic therapy or chemotherapy is inadvisable because the ordinary bacterial flora are replaced by resistant organisms The development of a pulmonary complication with this type of secondary infection is obviously most difficult to treat

TREATMENT OF PULMONARY COMPLICATIONS

Treat infection early specifically and adequately to prevent underventilation and hypoxia
Repeated tracheobronchial aspiration Less traumatic bronchoscopy may be done through the tracheotomy when usual suction is ineffective
Correct for the effect of these complications in diminishing ventilation and increasing pressure requirements in the respirator Prove adequacy of tidal exchange
Use humidified oxygen and/or steam therapy
Make frequent changes in body position postural drainage
Ephedrine (subcutaneously) 30 minutes prior to endotracheal suction Occasionally prolonged dosage may be necessary (25-50 mgm orally every 8 hours in the adult patient)
Treat myocardial insufficiency secondary to extensive pulmonary complications with digitalis (See page 58)
If hemoglobin is below 10 12 gms use repeated small blood transfusions

In addition to the measures previously outlined certain features are important in the satisfactory management of these complications They include (a) frequent bronchoscopy which is necessary for persistent atelectasis and whenever underventilation cannot be corrected by simple tracheal suction and reasonable respirator pressure adjustments (b) pulmonary complications account for decreased distensibility of the lung so that higher respirator pressures are necessary to accomplish adequate tidal exchange (c) oxygen therapy is often necessary (see page 47) and (d) occasionally serious impairment of cardiac function is observed and digitalization is necessary In many instances satisfactory treatment is possible

It should also be pointed out that upper lobe atelectasis may not produce serious impairment of pulmonary ventilation so that conservative treatment may be entirely adequate In contrast lower lobe atelectasis is usually due to an obstructing mucous plug or inspissated mucopus in a primary bronchus This condition requires immediate and energetic treatment because it almost always results in underventilation

METABOLIC DISTURBANCES IN ACUTE POLIOMYELITIS

Alterations of water and electrolyte homeostasis
- Dehydration
- *Hemoconcentration*
- Hypokalemic alkalosis
- Hyponatremia or hypernatremia

Alterations of oxygen uptake and carbon dioxide elimination
- Arterial oxygen unsaturation and oxygen debt (see page 48)
- Hypercapnia caused by underventilation
- Hypocapnia caused by hyperventilation

Alterations of serum pH adjustment
- Underventilation with CO_2 retention may produce acidosis pH less than 7.35 units (Arterial blood.)
- Hyperventilation with excessive CO_2 elimination may produce alkalosis pH more than 7.45 units (Arterial blood.)
- Changes in electrolyte distribution as a result of fever, altered general metabolism, state of hydration and renal function may produce either venous serum acidosis or alkalosis.

In the acute phase of poliomyelitis the problems of water and electrolyte metabolism are in many respects similar to those of any acutely ill patient. Poor intake gradually leads to deficits of both water and electrolytes. Excessive loss of gastric or oral secretions (the latter is particularly important in bulbar patients) *increases the magnitude of this deficit. In addition high* body temperature and respiratory disturbances such as hyperventilation increase insensible water loss. The continued loss of water in hypotonic secretions may lead to a marked water deficit. Salt loss is less apparent in the serum chemistries due to the presence of hemoconcentration, nevertheless total body deficits of salts are almost invariably present. Failure of adequate sodium replacement together with urinary sodium losses may lead to marked hyponatremia. Failure to replace potassium may lead to hypokalemic alkalosis.

Disturbances of oxygen uptake and carbon dioxide elimination are problems restricted to the severely ill patient and the respirator patient in particular. The disturbances in pH regulation are uncommon in the nonrespiratory patient provided water, electrolyte and caloric needs are met and underventilation or hyperventilation does not occur.

TREATMENT OF PULMONARY COMPLICATIONS

Treat infection early specifically and adequately to prevent underventilation and hypoxia
Repeated tracheobronchial aspiration Less traumatic bronchoscopy may be done through the tracheotomy when usual suction is ineffective
Correct for the effect of these complications in diminishing ventilation and increasing pressure requirements in the respirator Prove adequacy of tidal exchange
Use humidified oxygen and/or steam therapy
Make frequent changes in body position postural drainage
Ephedrine (subcutaneously) 30 minutes prior to endotracheal suction Occasionally prolonged dosage may be necessary (25-50 mgm orally every 8 hours in the adult patient)
Treat myocardial insufficiency secondary to extensive pulmonary complications with digitalis (See page 58)
If hemoglobin is below 10 12 gms use repeated small blood transfusions

In addition to the measures previously outlined certain features are important in the satisfactory management of these complications They include (a) frequent bronchoscopy which is necessary for persistent atelectasis and whenever underventilation cannot be corrected by simple tracheal suction and reasonable respirator pressure adjustments (b) pulmonary complications account for decreased distensibility of the lung so that higher respirator pressures are necessary to accomplish adequate tidal exchange (c) oxygen therapy is often necessary (see page 47) and (d) occasionally serious impairment of cardiac function is observed and digitalization is necessary In many instances satisfactory treatment is possible

It should also be pointed out that upper lobe atelectasis may not produce serious impairment of pulmonary ventilation so that conservative treatment may be entirely adequate In contrast lower lobe atelectasis is usually due to an obstructing mucous plug or inspissated mucopus in a primary bronchus This condition requires immediate and energetic treatment because it almost always results in underventilation

METABOLIC DISTURBANCES IN ACUTE POLIOMYELITIS

Alterations of water and electrolyte homeostasis
- Dehydration
- Hemoconcentration
- Hypokalemic alkalosis
- Hyponatremia or hypernatremia

Alterations of oxygen uptake and carbon dioxide elimination
- Arterial oxygen unsaturation and oxygen debt (see page 48)
- Hypercapnia caused by underventilation
- Hypocapnia caused by hyperventilation

Alterations of serum pH adjustment
- Underventilation with CO_2 retention may produce acidosis pH less than 7 35 units (Arterial blood)
- Hyperventilation with excessive CO elimination may produce alkalosis pH more than 7 45 units (Arterial blood)
- Changes in electrolyte distribution as a result of fever altered general metabolism state of hydration and renal function may produce either venous serum acidosis or alkalosis

In the acute phase of poliomyelitis the problems of water and electrolyte metabolism are in many respects similar to those of any acutely ill patient Poor intake gradually leads to deficits of both water and electrolytes Excessive loss of gastric or oral secretions (the latter is particularly important in bulbar patients) increases the magnitude of this deficit In addition high body temperature and respiratory disturbances such as hyperventilation increase insensible water loss The continued loss of water in hypotonic secretions may lead to a marked water deficit Salt loss is less apparent in the serum chemistries due to the presence of hemoconcentration nevertheless total body deficits of salts are almost invariably present Failure of adequate sodium replacement together with urinary sodium losses may lead to marked hyponatremia Failure to replace potassium may lead to hypokalemic alkalosis

Disturbances of oxygen uptake and carbon dioxide elimination are problems restricted to the severely ill patient and the respirator patient in particular The disturbances in pH regulation are uncommon in the nonrespiratory patient provided water electrolyte and caloric needs are met and underventilation or hyperventilation does not occur

The presence of an acid venous serum pH and low bicarbonate concen tration usually indicates metabolic acidosis associated with starvation fever, anhydremia and partial renal failure The presence of an acid arterial blood pH and a high bicarbonate content indicates respiratory acidosis due to severe ventilatory failure

The patient who is subjected to artificial respiration may develop marked shifts in carbon dioxide and pH regulation Hyperventilation which devel ops with the use of artificial respiration produces hypocapnia and an alka line shift in the arterial pH Slightly alkaline arterial pH (7 48 7 55) appears to be well tolerated by the respirator patient in the acute phase of the dis ease An alkaline pH shifts the oxyhemoglobin dissociation curve in the favorable direction of higher saturation at lower partial pressures of oxygen In direct contrast the respirator patient tolerates carbon dioxide retention and acidosis very poorly

CORRECTION AND MAINTENANCE OF WATER, ELECTROLYTE AND CALORIC NEEDS

INITIAL REPLACEMENT NEEDS FOR THE DEHYDRATED PATIENT

(based upon moderately severe dehydration and the absence of significant vomiting water and electrolyte losses during therapy)

	Total Na^+	Total K^+	Total Water	Total
	meq /Kg	meq /Kg	cc /Kg	Cal /Kg
Infant	3-4 8	2 3	150	40
Child	2-3	2	120	40
Adult	1 2	1 1 5	75-90	40

* (Total water needs are for the first 24 hours during treatment)

Replace water with 5-10% glucose invert sugar or fructose solutions in water

Replace salt with 0 85% Sodium Chloride and 0 3% Potassium Chloride solutions in water

Rate of fluid administration (assuming 15 drops = 1 cc)

Maximum of 3 cc (5 drops)/kilogram of body weight/minute for 1 to 2 hours then 2 cc (3 drops)/Kg /min for 4 to 6 hours

Remainder of solutions administered during the next 8 to 12 hours at a rate of 05 to 1 cc (1 2 drops)/Kg /min

Intravenous route of administration is preferred A Gardner Murphy polyethylene type of needle is the best

Calculate 24 hour needs of solutions and MIX

Example (30 Kg child)

	Composition	Amount	Totals
Solutions	10% Invert sugar in water	60 cc /Kg	1800 cc
	0 85% NaCl in water	20 cc /Kg	600 cc
	0 3% KCl in 10% invert sugar in water	40 cc /Kg	1200 cc
		Total water =	3600 cc
Analysis	120 cc of water/Kg /24 hours		
	96 meq of Na^+ as Na^+Cl^- = 3 2 meq /Kg		
	48 meq of K^+ as K^+Cl^- = 1 6 meq /Kg		
	Carbohydrate = 300 gms or 10 gm /Kg or 40 Cal /Kg		

A minimum of 12 Cal. per kilogram of body weight is required to spare protein breakdown.
Attempt to provide 30-40 Cal. per kilogram of body weight to meet nutritional requirements.

COMMON EQUIVALENTS (APPROXIMATE)

1 gm. Na^+Cl^- = 16 meq. Na^+ or 1 meq. Na^+ = 60 mgm. NaCl
1 gm. K^+Cl^- = 13 meq. K^+ or 1 meq. K^+ = 75 mgm. KCl
0.3% KCl = 40 meq. K^+/L or 4 meq. K^+/100 cc.
0.85% NaCl = 160 meq. Na^+/L or 16 meq. Na^+/100 cc.

Restoration and maintenance of good hydration in patients with acute poliomyelitis requires careful attention to the physiology of body fluids. Remember not only to give maintenance water and salt but also to replace antecedent deficits which may be large. Rate of administration of fluids will be determined by three factors: (a) severity of initial dehydration, (b) renal excretory capacity, and (c) the suitability of distributing reparative fluids over a 24 hour period. The urine specific gravity is an aid to the proper rate of fluid administration since high specific gravities indicate renal conservation of water in the face of insufficient intake or excessive extra renal loss. Salt replacement should not be excessive and can be followed by measuring the urine chloride excretion (bedside Fantus test for urine chloride).*

Urinary chloride excretion should be at least 3 grams per liter and optimally 5 to 7 grams per liter of urine and not more than 10 grams during parenteral fluid therapy. In the face of low serum chlorides, renal conservation of chloride ion will be reflected in a marked reduction of total chloride excretion.

Patients with low serum potassium or clinical evidence of hypokalemia are sometimes encountered in the course of rehydration. This should be treated in the same manner as a deficit of intracellular potassium with the addition of potassium salts. If the potassium requirements suggested above have been met this problem usually does not occur.

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* Fantus test[18] for urine chlorides. To 10 drops of urine in a test tube add 3 drops of a 20% solution of potassium dichromate. Then add in a dropwise manner a 2.9% solution of silver nitrate, shaking well with each drop. A reddish brown precipitate is immediately formed and then disappears with agitation of the test tube contents. The end point of titration is reached when the precipitate persists. Each drop of silver nitrate solution added to the end point indicates the presence of approximately 1 gram of chloride per liter of urine.

CORRECTION AND MAINTENANCE OF WATER ELECTROLYTE AND CALORIC NEEDS

MAINTENANCE NEEDS OF WATER, ELECTROLYTES AND CALORIES

The maintenance needs are determined by individual estimation of average daily requirements abnormal losses and antecedent deficits

Average requirements for a 30 Kg (66 lbs) child for 24 hours

Water—35-40 cc /Kg /day

85% NaCl—10 cc /Kg /day

0 3% KCl—30 cc /Kg /day

Calories—30-40 Calories/Kg /day

Normal water losses

Insensible loss (lungs and skin) is estimated to be from 25-30 cc /Kg /day It is greater in the infant and less in the adult

Renal loss (urine) averages about 10-15 cc /Kg /day for main tenance of functional capacity of the kidney It is greater in the infant and less in the adult

Abnormal water losses (This must be measured or estimated and added to the average if they occur)

Insensible losses may increase to 50 60 cc /Kg /day with high fever and increased pulmonary ventilation

Sweating in the tank respirator may add 30 60 cc /Kg /day

Removal of oral secretions in swallowing difficulty may be prodigious (500 1500 cc /day)

Polyuria or low urine specific gravity may increase renal water loss to 20 30 cc /Kg /day

Loss by vomiting increases requirements in direct proportion to amount of vomitus

Abnormal electrolyte losses

Skin—sweating is significant only in the presence of visible per spiration The electrolyte loss is largely sodium

Urine—potassium losses may be large especially with protracted polyuria Sodium and chloride losses may also occur

Vomitus and oral secretions are high in potassium and chloride content

Antecedent deficits of water
The deficit is proportional to the adequacy of the fluid intake in the first 24 hours of replacement When intake oral or parenteral fails to correct the initial dehydration this amount must be added to the above average needs

The purpose of the fluid and electrolyte therapy in the acute phase of the disease is to maintain homeostasis and to correct any dehydration as well as meet abnormal losses from fever, etc It is very important to steer a conservative course in fluid therapy which will avoid toxicity from either over or under hydration and too little or too much electrolyte

Water deficits can be considered to be isotonic in character Fluid lost from intracellular spaces requires potassium and that from extracellular spaces requires sodium and chloride for replacement

Particular attention should be given to insensible pulmonary water losses in the hyperventilated respirator patients Both sensible and insensible skin losses may be at the extremes mentioned in the box above particularly in hot humid climates in the absence of air conditioning

Occasionally the extensively paralyzed patient will develop inability to concentrate the urine and large volumes of urinary water loss will occur Therefore safe estimates of fluid requirements depend entirely on the accuracy of fluid intake and output measurements Stress in serious illness and from treatment procedures may complicate maintenance of electrolyte homeostasis Urinary losses of potassium may be prodigious in this situation and can be detected by measurement of potassium concentration in an aliquot of the total 24 hour urine collection The same flame photometer technique used for serum sodium and potassium measurements may be used with urine samples

CORRECTION AND MAINTENANCE OF WATER ELECTROLYTE AND CALORIC NEEDS

EVIDENCE FOR PROPER FLUID AND ELECTROLYTE THERAPY

Favorable signs

- Clinical improvement in hydration sensorium and quality of the pulse
- Production of a good volume of urine with a specific gravity between 1 010 and 1 020
- Urinary chloride excretion in the range of 3 to 7 grams per liter of urine (Fantus test—page 66)
- Three to five per cent weight gain in the first 24 to 48 hours

HAZARDS IN THE MANAGEMENT OF FLUID ELECTROLYTES

Overhydration—rate of fluid administration should not exceed suggested maximums and fluids should be distributed through out the 24 hour period Polyuria dilution of blood serum head ache vomiting weakness muscular twitches convulsions and coma can result from water intoxication

Underhydration—may occur when the estimate of current losses is inadequate or when scheduled fluid therapy is not received Hyperosmolarity of the serum may occur and a febrile reaction can develop

Potassium intoxication—may occur when the patient is oliguric or anuric This leads to hyperkalemia subsequently muscular weakness and cardiac arrest

Sodium and chloride retention—may result if stress is severe and prolonged as a result of the disease Estimates for sodium re quirements should be on the low side when there is any doubt about the patient s needs Hypernatremia can lead to edema and increased extracellular fluid volume with the development of cellular potassium deficiency

Every effort should be made very early in the post acute phase of illness to insure a dilute urine which does not exceed a concentration of 1 020 Otherwise the rather prompt hypercalcemia and hypercalcuria which develops from immobilization in the paralyzed patient may produce stone

formatıon The critical concentration of calcium ın the urine ıs 15 mgm 30 mgm per cent so lower concentrations must be maintained by urinary dilution

Considerable attention ın the past has been given to keeping the patient ın a slightly dehydrated state to prevent cerebral edema This ıs dangerous since the maintenance of optimal water and electrolyte homeostasis by proper fluid therapy ıs an essential requirement for the integrity of cellular metabolism Failure to maintain fluid and electrolyte balance compromises the patient and may unfavorably influence recovery

The electrocardiogram ıs a valuable tool for the detection of metabolic disturbances at the extracellular and cellular levels insofar as myocardial function ıs concerned Hypokalemia hyperkalemia and abnormalities of serum ionized calcium concentration can be detected by changes ın the electrocardiogram[19, 20, 21]

DIET AND TUBE FEEDING

CRITICAL PHASE

Maintain fluid and electrolyte balance

Only calories are important in diet to provide minimum intake of 40 cal /kg body weight as carbohydrates

POST ACUTE PHASE

PATIENT ABLE TO SWALLOW

Begin with regular soft diet

If soft diet is tolerated for 48 hours then unrestricted diet is permitted except to limit milk and milk containing foods as a source of high calcium to one (1) pint per day in patients with extensive paralysis

Limit calories if obesity develops

PATIENT UNABLE TO SWALLOW

Nothing by mouth should be attempted

Tube feeding is started after height of acute phase has passed

Begin with parenteral fluids by gravity naso gastric drip in calculated amount (See page 67)

If no vomiting occurs in 24 to 48 hours add skim milk and strained orange juice fortified with glucose for the next 24 hours Example Adult 200 cc of skim milk or orange juice alternating each every 3 hours

Change skim milk to whole homogenized milk in the next 24 hours Continue to meet total water requirements with added water and orange juice

Then start formula calculated for adequate amounts of calories protein carbohydrates fat and total fluid volume Calcium intake should be restricted to 250 mgm /24 hours Fat particularly in early convalescence is poorly tolerated

INITIAL NUTRITIONAL REQUIREMENTS (Approximate)

Protein needs
- Under 1 year–3 5 gm /kg
- 1 to 3 years–2 gm /kg
- Over 3 years–1 gm /kg

Fat–1 gm /kg –usually not over 50 60 gms except for very large adults

Calories–40 cal /kg

Carbohydrates–make up to total calculated caloric requirements

CONVALESCENT PHASE

Foods to meet nutritional requirements can be obtained from a regular soft diet The foods are then blended in an electric blendor and diluted to a consistency that can be injected with a 50 cc syringe through a naso gastric tube Ground meat and hard boiled egg are good low calcium sources of protein Pureed baby meats do not pass through tubes easily Liver is recommended twice a week

Corn, eggplant, steamed rice and all dry cereal products do not blend well Avoid beans which are a source of high calcium content

Use fruit juices fortified with glucose as largest source of carbohydrates and as convenient diluting fluid so final volume will not be too great

Currently available commercial tube feeding preparations are all high in calcium content

During the first 24 hours use one half calculated amount of food diluted with water to make up full calculated volume

Add water and salt between meals to meet total daily requirements Sufficient potassium is available in foodstuffs and orange juices unless abnormal renal losses are encountered Remember all cooking in special diet kitchens is usually salt free

Add supplementary vitamins B and C Avoid high vitamin D intake

Example	Example of Contents of blend for one meal
R B 23 years W M 69 kg	
600 cc blend each feeding at	
8 a m	Ground meat 90 grams
12 noon	Mashed potatoes 100 grams
5 p m	Fruit juice 500 cc
H O 300 cc at	One hard cooked egg
10 a m	If needed give residual blend
2 p m	from previous meal
Orange juice 200 cc at	
8 p m	
Fruit juice 350 cc at	Once daily add vitamin concentrate containing B and C
10 p m	
6 a m	

Analysis		Total calories/24 hrs = 2700
Total calories in blend = 1866		
protein	70 gms	
fat	60 gms	
carbohydrates	239 gms	

Rest of 24-hour calorie need met with fruit juices with 5% added glucose = 60 cal /100 cc or 10% added glucose = 90 cal./100 cc

In general as soon as possible the contents of a regular soft diet which can be blended in an electric mixer such as the Waring Blendor® should be given by tube since the normal diet best meets the nutritional requirements of the patient. The Mead Johnson Naso gastric Tube* is preferable because it is of proper size and has an end opening rather than the easily clogged side openings A dietary food supplement such as MorCal® can be added in amounts of one to two tablespoons per blend feeding Abnormal electrolyte intake can be avoided with this technique Water and juices make suitable diluents for proper consistency of feeding

The psychic satisfaction of consuming a regular diet albeit blendorised and by tube is exceedingly important for the well being of the patient who cannot swallow The child especially enjoys taking his food trav and prepar ing the tube feeding

® Waring Blendor is manufactured by the Winsted Hardware Manufacturing Company Winsted Connecticut.

* Available from Mead Johnson Company Evansville, Indiana.

® MorCal is the proprietary name of a high calorie food supplement made available by Schenley Laboratories New York N Y

URINARY BLADDER RETENTION

ACUTE STAGE

OCCURRENCE

Bladder retention and inability to void spontaneously, usually develops with bilateral lower extremity paralysis and abdominal muscle paralysis and is more common in males

TREATMENT

If catheterization becomes necessary use an indwelling catheter inserted with the strictest attention to sterile technique

Maintain a dilute urine of large volume (1 010 to 1 020) by forcing oral fluids

Culture the urine repeatedly to determine the nature of infecting organisms if infection is suspected

Treat only for systemic infection indicated by pain burning sensation fever leukocytosis and pyuria A positive urine culture alone is not the indication for antibacterial therapy

Direct the selection of antibacterial drugs by the sensitivity of cultured organisms

Prophylactic use of systemic antibacterial agents is inadvisable and treatment of positive urine culture without evidence for infection may promote the development of infection by resistant organisms

REMOVAL OF CATHETER

Attempt removal as soon as acute symptoms subside

Clamp off the catheter for 3 to 4 hour intervals and encourage the patient to void spontaneously at the end of these periods

If the patient fails to void spontaneously at the end of 24 hours *of encouragement use prostigmine subcutaneously* (1 0 mgm in adults) and intramuscularly Apply firm pressure with the palm of the hand to the suprapubic bladder area Repeat the drugs once in 20 minutes if there is no result

If the patient is still unable to void recatheterize and again attempt removal in 48 hours

POST ACUTE STAGE

The penalty for failure to remove the catheter early is infection
In the presence of infection perform a cystometrogram to rule out incomplete emptying and residual urine as a provocative condition
Persistent infection in the catheterized patient may respond to tidal drainage or irrigation of the bladder every 4 hours with an antibacterial solution such as Suby s solution This is combined with systemic chemotherapy

Conservative measures are usually adequate for the management of this condition in children and catheterization may be avoided Frequent stimulation of voiding to prevent over distention of the bladder and stimulant drugs such as prostigmine and Urecholine® are important adjuncts to conservative therapy

Organisms may grow out of the urine even though natural defense mechanisms have prevented invasion of tissues For this reason continued use of antibacterial agents in prophylactic doses may promote the establishment of a resistant bacterial flora which can be very difficult to eradicate should infection occur

Suby s solution—26 gms of magnesium oxide 128 gms of citric acid made up to 4 000 cc with distilled water
® Urecholine is the brand name of the urethane of β methylcholine chloride made available by Sharp & Dohme divis on of Merck and Co Rahway N J

MANAGEMENT OF CONSTIPATION AND IMPACTION

PREVENTION IS BEST—NORMAL FLUID INTAKE AND DIET ARE IMPORTANT

ENCOURAGE ELIMINATION AT REGULAR INTERVALS

Use Dorbane® once daily at bedtime for constipation
Dosage children 37 5 75 mgm
adults 75 150 mgm
If obstipation develops utilize saline soap suds enemas followed by an *oil retention enema if necessary*
Manually break up and remove fecal impactions with well lubricated gloved index finger
Do Not Exhaust Patient
Feces formation is minimal during parenteral alimentation

CAUSES

Dehydration—minimal bulk in diet
Absence of effective abdominal muscle contraction with increase in intra abdominal pressure
Distention of bowel and disturbances in motility

Dorbane® used prophylactically has been successful in most instances in establishing regularity and avoiding impactions Frequently the dosage may be decreased successfully after 6 weeks

Patients with fecal impactions may complain of abdominal discomfort, nausea and vomiting Objectively impaction can be noted by abdominal distention by palpation of the abdomen or by difficulty in inserting a rectal thermometer or rectal tube

® Dorbane is the brand name of dihydroxy anthraquinone made available in 75 mgm scored tablets or oral suspension by the Schenley Laboratories Ltd. New York 1 N Y

Never give more than two successive enemas especially to the respiratory patient The enemas should be made up of saline to avoid loss of electro lytes from the bowel If after two enemas good results have not been obtained the patient should be allowed to rest a few hours Then he should be given an oil retention enema and placed in a slight head down position for one-half hour which aids the patient in retaining the oil Patients with severe constipation may benefit by an oil retention enema the night pre ceding saline soap suds enema

The danger of exhausting the patient is always present and treatments should be spaced over a period of hours or days depending on the number of treatments necessary and the patient s condition The respiratory patient is especially distressed when suffering from a fecal impaction and usually requires maximum breathing aid if prolonged treatment is necessary

PREGNANCY COMPLICATING ACUTE POLIOMYELITIS

OCCURRENCE

Pregnancy increases susceptibility to acute poliomyelitis The disease may develop at any time during the period of gestation

Maternal mortality in poliomyelitis does not appear to be greater because of pregnancy

Fetal mortality is increased

- Spontaneous abortion is common in the first and second trimester of pregnancy
- Duration of gestation may be shorter than normal especially if the disease occurs in the last trimester

PRE NATAL MANAGEMENT

The course of the disease usually does not modify the obstetrical management

- Complications of pregnancy are treated in the same fashion as in the non poliomyelitis patient
- Caesarean section is not indicated except for obstetrical conditions Acute bulbo spinal paralysis with intractable respiratory insufficiency may be an exception

Pregnancy is very uncomfortable for the extensively paralyzed patient Careful positioning and frequent changes in body position must be carried out and the head down body position should be avoided

- The physical therapist should stretch out the hip musculature especially the adductors and internal rotators so that the position of delivery will not be painful

The combination of pregnancy and respiratory muscle paralysis often produces progressive insufficiency in the last trimester after cessation of acute involvement

- Both vital capacity and tidal volume may decrease coincident with uterine enlargement
- Increases in pressures will be required for adequate ventilation in the tank respirator
- Abdominal discomfort may be relieved by elevating the head end of the respirator cot and side lying positions

The patient should become accustomed to the dome respirator or intermittent positive pressure breathing devices such as the Bennett respirator for obstetrical examination nursing care and eventually delivery
The cuirass respirator and rocking bed are contraindicated because of discomfort and ineffectiveness
Induction of labor in the last 4 weeks of pregnancy may be advisable if there is evidence of toxemia or if severe genitourinary infection develops

In poliomyelitis complicated by pregnancy maternal fatality occurs in those cases with severe respiratory involvement Death is usually a result of the severity of the disease or failure to recognize the progressive respiratory insufficiency induced by the pregnant state in most respirator patients

The patient should be carefully observed for the presence of toxemia of pregnancy Fluid and electrolyte balance should be regulated to avoid salt and water retention with edema formation This may develop more readily in the pregnant poliomyelitis patient Similarly nutritional care is particularly important in the last trimester of pregnancy Provision of supplementary iron preparations and vitamin intake is necessary Do not give added calcium or vitamin D because of demineralization resulting from the disease process and immobilization

The nursing care of the respirator patient is of utmost importance Comfortable positioning should be achieved at all times

The expectant mother should be frequently reassured that the chances are very much in her favor for a healthy baby and an uncomplicated delivery She is apt to become very discouraged and even depressed in the last months of gestation There is not a greater trial for a woman than tank respirator confinement in pregnancy Considerable reassurance can be given for improvement in breathing after delivery If mental depression becomes a severe problem minimal oral doses of 50 to 100 mgm per day of Thorazine® may be of value With use of such drugs somnolence or stupor must be avoided since airway obstruction readily develops in the supine respirator patient

® Thorazine is the brand name of chlorpromazine made available in 25 mgm tablets or in 1 cc 25 mgm ampoules for parenteral dose by Smith, Kline and French Laboratories Philadelphia Pa

CONDUCT OF DELIVERY OF THE RESPIRATOR PATIENT

Four weeks prior to the expected date of delivery all necessary equipment and sterile packs for delivery should be kept in the patient s room as well as an incubator

The anesthesia service should be alerted

Spontaneous labor and vaginal delivery proceed rapidly and uneventfully in most instances The expulsive action of the normal uterine musculature is surprising when it is unop posed by voluntary musculature

Conservative obstetrical analgesia with Demerol® is permissable in a dosage range of 50 75 mgm every 3 to 4 hours Somno lence in the supine position may lead to upper airway ob struction by the relaxed tongue and glottis Minimal sedation is advisable

Local Pudendal nerve block may be employed for delivery Spinal anesthesia is not indicated

Normal conduct of delivery is carried out on the tray of the respirator utilizing the dome of the Emerson respirator for artificial respiration or mask intermittent positive pressure with supplementary oxygen by positive pressure respirator or anesthesia bag *

Prevent maternal respiratory insufficiency and consequent fetal distress

The newborn infant can be kept in the isolation wing of the hospital nursery for a period of 10 to 14 days as a precaution ary measure

POST PARTUM CARE

Usually uncomplicated

The vital capacity is found to increase fairly promptly after delivery and respiratory improvement usually follows

® Demerol is the brand name of meperidine hydrochloride made available by Winthrop-Stearns Inc New York 18 N Y

Bennett Pressure Breathing Therapy Unit Model HR-5A flow sensitive Available from V Ray Bennett and Associates Inc Los Angeles Calif

Monaghan Bennett Positive Pressure Attachments for tank respirator or Monaghan cuirass respirator pump available from J J Monaghan Company 500 Alcott Street Denver Colorado

Huxley Positive Pressure Attachment. Available from Technicon Huxley Ltd New York N Y

Emerson Dome Respirator Available from J H Emerson Company 22 Cottage Park Cambridge Mass

Lactation may be difficult to discontinue in those patients utilizing the cuirass respirator in the post partum respiratory program because of physical stimulation and aspiration of the breast

The partly weaned respirator patient who still utilizes the cuirass respirator or rocking bed as the primary breathing aid may have to return to the tank respirator full time in the last trimester Respiratory insufficiency with the use of the lesser aids in the pregnant patient may develop easily and should be avoided by restricting artificial respiration to the tank respirator except for nursing care and obstetrical examination

NURSING CARE—ACUTE POLIOMYELITIS
ROUTINE ORDERS (S W P R C)

On admission apply a tuberculosis patch test (for children 6 months to 14 years), and obtain complete blood count urinalysis serology, weight and height

Take temperature pulse respiration and blood pressure every 4 hours (unless ordered more frequently)

Observe patient for Signs and Symptoms of Serious Polio (page 15) The physician should be notified of the occurrence of such signs and symptoms as well as any changes in vital signs

Charting should be accurate and detailed on the acute patient Chart any progression or change of vital signs and carefully note time

No Sedation or Aspirin should be used unless ordered

Hot packs for pain should be specifically ordered by the physician

Catheterizations are performed only by the nurse or physician Orderlies and practical nurses are not permitted to catheterize patients on Polio Service

All acute patients in a respirator must be protected by respirator alarms at all times

Use Only Electrical Outlets with Emergency Protection for Power Failure for respiratory equipment **Do not** plug any other type of equipment *into these outlets*

Oxygen is always administered with humidification (see page 49)

SERIOUS POLIOMYELITIS

See **Signs and Symptoms of Serious Polio, Early Indications and Tests of Swallowing Impairment, Immediate Measures in the Treatment of Impaired Swallowing Evidence of Progressing Swallowing Impairment, and Signs and Symptoms of Respiratory Muscle Paralysis**

If there is any mucous accumulation in the throat incline the patient s body with head down and place on his side or abdomen only, not on his back

Nothing should be given by mouth including fluids and ordered medications

Have suction equipment available at bedside at all times

Check bronchoscopy and tracheotomy bedside tables for completeness and operation Know Which Ear, Nose and Throat Physician Is On Call and advise him of the patient s condition
Always have a respirator available checked and ready for use

These routine orders are a part of the standing nursing orders for acute admissions of the Southwestern Poliomyelitis Respiratory Center

The **PRINCIPLES OF NURSING CARE** which are necessary for poliomyelitis programs in the large hospital with an acute patient load include

BEDSIDE NURSING The gentle assistance of the nurse who is aware of the importance of preserving the dignity of the physically handicapped individual is the essence of polio nursing The nurse attempts to provide for the needs of the individual patient through close observation of his changing responses to illness including vital signs general condition physical appearance and mental attitudes Satisfactory bedside nursing includes an appreciation of the patient s exaggerated and demanding emotional reactions to catastrophic illness which are entirely normal (See page 95) Although specific medical orders are paramount cleanliness good body positioning and performance of range of motion are also essential for proper care Social and recreational needs may require more than ordinary attention by the nurse but such needs must be fulfilled Cooperation with special services such as social service if they are available assists the nurse

PRACTICE OF GROUP NURSING is the most efficient utilization of personnel and contributes to a favorable climate for rehabilitation which cannot be achieved in the private care of the patient isolated in a small hospital room One nurse and one or two aides can better meet the needs of three respiratory patients in one large room than can three nurses with three patients in three private rooms

Grouping of patients according to age sex interests and degrees of involvement is particularly desirable In spite of the loss of personal privacy the association of patients with the *same type of handicap actually* brightens the patient s outlook and simplifies and reduces nursing demands Seclusion and special duty nursing encourages a pattern of over dependency and excessive emotional identification which may seriously impede the rehabilitation program since the patient is less apt to depend upon other members of the treatment team

Group nursing permits rotation of personnel at periodic intervals This rotation minimizes excessive patient and nurse emotional interdependence and also enlarges the scope of the nurse s experience to include patients making rapid recoveries as well as those who are progressing slowly The nurse deserves the opportunity to observe and participate in successful patient care as does any member of the treatment team

IN SERVICE EDUCATION and frequent orientation by means of staff conferences are necessary for the maintenance and improvement of any treatment program Educational efforts should include a concise understanding of the entire medical program and its aims together with a thorough knowledge of all respiratory and special equipment Frequent practice periods for hand operation of respiratory equipment and emergency tests should be carried out This reassures the respiratory patient and helps obtain his confidence in the nursing staff

EXPANDED NURSING SERVICES for poliomyelitis care cannot achieve an ideal ratio of nurses to patient load and it is necessary to train and use non professional workers Originally a substitute measure this has demonstrated that professional nursing hours can be safely and correctly reduced The use of well trained aides attendants and orderlies is a realistic and practical solution to staffing

Non professional workers require excellent orientation close supervision promotion for real ability and continuing in service education They are especially valuable if they work as a part of nursing teams under the supervision of a *registered nurse*

NURSING CARE—HYGIENE

ORAL	Toothbrush toothpaste emesis basin for routine mouth care Special mouth care as indicated especially to patients not receiving oral feedings
SKIN CARE	Special emphasis to neck, back and bony prominences
BATH	Complete daily bed bath Include range of motion to all extremities during bath Do not apply lotions and powders Keep skin clean and dry at all times
SCALP	Massage daily with a hair brush to prevent pressure areas Shampoo once a week Patients may and should be shampooed when confined to a tank respirator Shampoo with Selsun® if greasy scalp scales develop
LINEN	Clean dry linens are required at all times Avoid wrinkles in sheets An extra draw sheet may be placed under the patient to facilitate turning
ELIMINATION	Patients should be closely observed for bowel and bladder elimination (See Management of Constipation and Impaction Page 76)
TOES AND FEET	Daily soaking of the feet in soapy water followed by vigorous rubbing and drying with a towel to remove accumulated dead tissue Trim the nails straight across once a week Do not pry under the corners of the nails

® Selsun is the proprietary name of selenium disulfide 2½% w/v in a suspension containing emulsifying buffering and carrying agents and is made available by Abbott Laboratories North Chicago Illinois

Patients confined to the tank respirator demand and deserve excellent nursing care Any nursing care procedure which should be performed for a critically ill bed patient should also be carried out for the tank bound patient by working through the portholes Special attention must be given to the prevention of pressure areas especially of the neck, shoulders back and heels Frequent turning is one of the best preventive measures Special attention to back care must be a routine procedure Neck care may be accomplished by soaping hand and massaging soap well into the neck This serves to stimulate circulation and toughen the skin This procedure may be done while the patient is in the tank and without loss of pressure only when using the standard sponge rubber collar A piece of foam rubber not more than one half inch thick, wrapped in a soft diaper and placed around the neck serves as an excellent neckpiece both for patient comfort and for relief of pressure from the lung collar

The severely involved patient is susceptible to ingrown toenails and infections due to lack of normal use of the feet and decreased circulation Preventive measures include daily foot care and training of personnel to avoid bumping the feet when moving the patient

NURSING CARE—TRACHEOTOMY

CONTROLLING SECRETIONS

Remove inner cannula frequently and soak in a solution of equal parts of 2% hydrogen peroxide and water

Select soft rubber catheter with two holes one on each side of the tube blunt end preferable to sharp angle cut and use separate catheters in separate containers for oral nasal and tracheal *suction*

Use a Y tube in the suction line to control pressure Insert the catheter approximately one inch below the end of the tracheotomy tube close the open arm of the Y tube to produce suction and gradually withdraw the catheter with rotation [23]

Allow the patient to rest before repeating procedure

If secretions are thick and tenacious instill about 1 to 1½cc of sterile normal saline into tracheotomy tube with rubber tipped medicine dropper prior to suctioning

Suction until respirations are free of rhonchi and wheezing—listen with the bell of the stethoscope over the tracheotomy tube

Clean soaked inner cannula by running a pipe cleaner through it and replace

By turning the patient s chin to the left the catheter will pass into the right main bronchus and vice versa

Do not suction constantly Give the patient a chance to breathe!

The patient should NOT be left alone at ANY time!

DANGER SIGNS

Blue ashen color—dilation of nostrils

Bleeding from tracheotomy wound

Noisy respiration which cannot be relieved by suctioning

Inability to make patient breathe comfortably

Inability to insert catheter due to obstruction Do not force catheter into tracheotomy tube Crusts may be dislodged from the tube and aspirated

Aspiration of blood clots or large amounts of bloody mucus

Care in the *respirator is facilitated* by the use of an extra large extra thick sponge rubber tracheotomy collar and tracheotomy collar depressor The collar must be retracted sufficiently to avoid "riding" on the tracheotomy tube A foam rubber neckpiece wrapped in a soft diaper provides an effective seal if lapped around the neck and crossed over the supra sternal notch

Patients confined to the tank respirator demand and deserve excellent nursing care Any nursing care procedure which should be performed for a critically ill bed patient should also be carried out for the tank bound patient by working through the portholes Special attention must be given to the prevention of pressure areas especially of the neck, shoulders back and heels Frequent turning is one of the best preventive measures Special attention to back care must be a routine procedure Neck care may be accomplished by soaping hand and massaging soap well into the neck This serves to stimulate circulation and toughen the skin This procedure may be done while the patient is in the tank and without loss of pressure only when using the standard sponge rubber collar A piece of foam rubber not more than one half inch thick wrapped in a soft diaper and placed around the neck serves as an excellent neckpiece both for patient comfort and for relief of pressure from the lung collar

The severely involved patient is susceptible to ingrown toenails and infections due to lack of normal use of the feet and decreased circulation. Preventive measures include daily foot care and training of personnel to avoid bumping the feet when moving the patient

As soon as the prerequisites are present removal procedures should be started Remove the tracheotomy tube even if some suctioning is necessary since mucus will be present as long as the tube is in place

In rare instances it may be advisable to leave the smallest possible tracheotomy tube or a solid plastic replica in place to maintain the tracheostomy for emergency suction Completely apneic patients those with persistent and severe swallowing impairment and also those with repeated episodes of pneumonitis and atelectasis may require a tracheotomy for prolonged periods

REMOVAL OF THE TRACHEOTOMY TUBE

PREREQUISITES

- Ability to swallow fluids and solids without aspiration This is tested by giving the patient green vegetable colored water to swallow If the green water is recovered from the trachea the patient has aspirated
- Absence of *pulmonary pathology upon x ray examination*
- Demonstration of effective swallowing with Dionosil® by fluoroscopy
- Direct laryngoscopy to rule out presence or persistence of vocal cord paralysis

DISADVANTAGES OF RETAINING TUBE

- Stimulation of excessive secretion so long as foreign body (tube) is in the trachea This necessitates more nursing care and interferes with the accurate evaluation of the breathing reserve
- Slower progress in weaning from respiratory aids is often observed
- Addiction to unnatural airway occurs especially in children

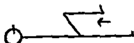
PROCEDURE

- If a large tube was used decrease the size and length over a period of several days
- Close the tube during the day for several periods and for as long a time as can be tolerated Open only for suction
- Gradually close for 24 hour periods
- After two or three days remove the tube
- Use artificial coughing devices and coughing maneuvers to prevent accumulation of secretions
- Steam inhalations for two or three days may help liquefy secretions
- If removal failure occurs (rarely) replace the tube
- Obtain tracheal culture and sensitivity tests and place patient on prophylactic antibiotics before attempting removal in the next one or two weeks

5 Rotation in the Tank Respirator Cross the far leg over the near leg Place one hand under the hip and the other on the far shoulder Hold the shoulder down and pull the hip over toward you twisting the trunk

HIPS

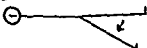
1 Flexion Place one hand under the knee and one under the ankle Flex the hip and knee bringing the knee toward the chest.



2 Hamstrings and Quadriceps Flex the hip to 90 and hold it there Extend the knee and then flex it by lifting at the ankle



3 Abduction With one hand under the knee and one under the ankle move the leg out to the side to a 45° angle



4 Rotation Place one hand on the knee and one on the foot. Roll the leg in and then roll it out

FOOT

1 Dorsi and Plantar Flexion Place one hand on the heel and the other on the forefoot (a) Pull the heel down and push the forefoot up and (b) Pull the forefoot down and push the heel up



2 Inversion and Eversion Place one hand on the leg just above the ankle and the other on the forefoot Turn the foot in and out

3 Toe Flexion and Extension Place one hand on the forefoot and the other over the toes Bend the toes down and then bring them back straight

SHOULDER

1 Flexion Place one hand under the elbow and one supporting the hand Raise the arm straight up and bring it back toward the bed



JOINT RANGE OF MOTION

NECK

1 **Flexion** Lift the head bringing the chin up to the chest

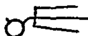


2 **Lateral Flexion** Move the head laterally bringing the ear to the shoulder



3 **Rotation** *Rotate the head turning the face completely to the left* and then to the right

4 **Extension** Extend the neck This can only be done in the side-lying or face lying positions or if the patient is in the tank respirator it can be done by lowering the head piece

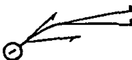
 

TRUNK

1 **Flexion** Flex the back by raising the head and shoulders bringing the head towards the knees

2 **Lateral Flexion** Place your arm under the patient s neck and your hand under the opposite scapula Pull the patient toward you lat erally flexing the trunk Hold the opposite hip down if he starts to move as a whole



3 **Lateral Flexion in Tank Respirator** Support both legs with one hand *under the thighs and the other under the ankles* and pull the legs and hips toward you



4 **Rotation** Place one hand on the pelvis on the far side and the other under the scapula Hold the pelvis down and rotate the upper trunk toward you in a twist

SIGNIFICANT SOCIAL AND EMOTIONAL FACTORS IN POLIOMYELITIS

DIAGNOSIS OF POLIOMYELITIS CARRIES WITH IT A SUPER EMOTIONAL CHARGE

Unpredictability of outcome in the acute stage arouses anxiety in the patient and patient s family

Element of contagion causes
- Patient concern about other members of family
- Family concern about other members
- Reaction of neighborhood and community

Widespread dramatization of disease by press radio television
- Serves to arouse guilt in parents regarding observation of publicized precautions
- General idea of outcome either permanent severe crippling or death

Feeling of stigma arising from erroneous idea on the part of the public that occurrence of poliomyelitis is associated with inadequate personal and household hygiene substandard living conditions

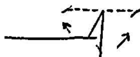
Financial worry

The Medical Social Service Worker can act as a bridge between the anxious family and the busy physician in establishing rapport and detecting social situations which may influence the patients and families acceptance of the medical program of management. Proper direction and utilization of social service activities by the physician will frequently help minimize and redirect the serious emotional and social consequences of this disease Effective execution of home care planning and follow up depends on early and consistent medical social service coordination

2 **Abduction** Using the same holds take the arm out to the side to a 90° angle



3 **Rotation** Place the arm in abduction and flex the elbow to 90° Maintain this position of the shoulder and elbow and take the hand back toward the bed Then move it forward in an arc toward the bed



ELBOW

1 **Flexion and Extension** Hold at the wrist and flex the elbow bringing the fingers to the shoulder then straighten the elbow



2 **Supination—Pronation** Hold the elbow flexed to 90° Then turn the hand so that the palm is toward the face and then turn it in and around toward the feet

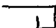
WRIST

1 **Flexion—Extension** Hold the elbow flexed to 90° and then flex and extend the wrist

2 **Abduction—Adduction** With the elbow flexed to 90° move the wrist medially and laterally

FINGERS

1 **Flexion** Flex the elbow to 90° and hold at the wrist to keep it from moving Place *your other hand over the dorsum of the fingers* and curl them down into the palm Each of the three joints normally goes to a right angle



2 **Extension** Using the same positions straighten the fingers

3 **Abduction** Spread the fingers apart and then bring them together

THUMB

1 **Flexion** Bring the thumb across the palm of the hand to the base of the little finger

2 **Extension** Bring the thumb back to a right angle with the palm

3 **Abduction** Bring the thumb directly forward from the forefinger

4 **Opposition** Touch the tip of the thumb to the tip of the little finger

EMOTIONAL PROBLEMS ASSOCIATED WITH EXTENSIVE PARALYSIS OR RESPIRATORY INVOLVEMENT

Disturbing emotional attitudes are usually natural transitory and rarely pathological considering the patient, the disease staff attitudes and the requirements of treatment

REACTIONS AT ONSET

- Severe anxiety apprehension and fright
- Confusion and occasionally a true delirium
- Stupor or extreme somnolence resembling a coma

REACTIONS IN THE POST ACUTE AND CONVALESCENT PHASE

- A shock like unawareness of severity of illness
- Passivity and inattentiveness
- Negativism dependency
- Emotional lability ready laughing and crying night terrors strange dreams
- Guilt feelings leading to self blame or punishment as the cause of the illness
- Guilt feelings leading to resentment or open hostility to staff and family usually verbal

THERAPEUTIC IMPLICATIONS

- The patient should feel that he is receiving the best possible care so that every effort must be made to provide it Proper operation of respiratory equipment if needed indicates quite objectively the competence of the staff
- Understand the normal emotional reactions to catastrophic illness and the need for them Include the family in this understanding
- Maintain a consistent optimistic but realistic approach to the patient and family from the onset of the disease in discussing his condition the treatment program and the prognosis Time exposure to other patients similarly involved and truthful information lead to early establishment of the healthy attitudes permitting the best possible life under the circumstances

SIGNIFICANT SOCIAL AND EMOTIONAL FACTORS IN POLIOMYELITIS

LONG TERM HOSPITALIZATION

Frequent and considerable reassurance is required by the family during the isolation period
Small children frequently fear they have been deserted by family
Prolonged hospitalization places strain on family relationship
Sacrificing of privacy is difficult for some patients in the communal type of living found in the hospital
Financial hardships if family wage earner is the patient
Care of home and children if housewife is patient
Narrowing of interests with attention focused on physiological functioning results in an introverted patient
Illness resulting handicaps and long term hospitalization accentuates any pre existing faulty personality structures in patient and members of family

PHYSICAL IMPAIRMENT

Inability of patient and/or members of family to accept the inevitability of some degree of physical handicap
Need for adjustment to new way of life imposed on patient and family
Relatives frequently become over protective toward patient
Conflict in patient around dependency vs independency
Special adaptation of home and physical environment—
Coordination of community resources
Lack of resources
Change or modification of vocational goals
Attitude of employers toward handicapped individuals

realize that the patient s hostility is not really personal but only symptomatic of a general feeling The patient should receive friendly understanding and clear direction by the staff He must have the opportunity to "talk his feelings out" This is usually all that is necessary

Following this initial period after one and a half to three months a later emotional disturbance may develop It reflects the rigorousness of the treatment program the honesty of staff attitudes the speed of recovery and the *patient s awareness of a prognosis indicated by exposure to others similarly* handicapped This period is characterized by mental depression withdrawal and lack of interest or cooperation It indicates that the patient has begun to appreciate the meaning of his physical incapacity the length of the required treatment and the significance of his illness in his own and his family s lives This may be thought of as a protective "buffering" reaction since it really indicates his efforts to face the illness and to struggle with a rearrangement of his life Thus there may be times when indicated medical procedures need to be adjusted to the emotional readiness of the patient Careful grouping and rearrangement of patients is often advantageous in promoting better insight It is most important at this time to expose the patient to individuals who have completed hospitalization who are home and living successfully within similar handicaps

Occasionally a staff member becomes alarmed and feels that this is an abnormal reaction and a psychotic episode However it is usually an expected occurrence which requires a non critical attitude and staff acceptance so that time and association with others plus emphasis upon what the patient has accomplished will prove beneficial

Unfavorable family behavior their problems and emotional attitudes directly affect the patient s condition and his recovery It may be possible *to understand the patient only after considering what is happening to his* family

Undoubtedly patients who were emotionally insecure before illness have an unreliable personality structure with poor family and job relationships They will demonstrate acute aggravation after severe poliomyelitis Nonetheless most patients follow a better course and manage to surmount physical handicap and resume a useful life

The patient s motivation for recovery is encouraged by any return of upper extremity muscle power which can be used in self help activities such as feeding writing typing etc This comes about most readily with good general medical and physical *medical care from the beginning* It should include friendly natural surroundings the gradual resumption of personal responsibilities and constructive staff attitudes and assistance

Recognize the emotional components of severe fatigue and stress from injudicious management or intercurrent complications of a medical nature Brain damage only occurs in the patient compromised by asphyxia and anoxia Damage from such episodes seriously limits the recovery of the patient and requires limitation of activity goals for any improvement

Regularly encourage the patient to talk about anxieties fears and dissatisfactions to a neutral" person who is not directly involved in the treatment program

Recognize the effect of staff attitudes upon the patient and that a medical staff must sample the gratification of successful treatment

PRESERVE THE INDIVIDUAL PATIENT'S DIGNITY AND FEELING OF INTEGRITY!

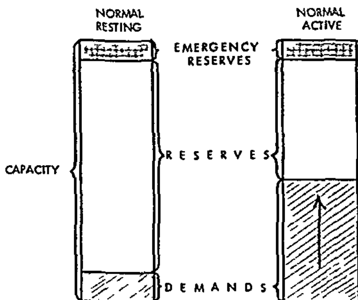
It is normal for an individual to experience anxiety when confronted with a crisis Since severe poliomyelitis is a major catastrophe severe anxiety should occur In some patients involvement of the brain stem by the disease may enhance the anxiety state

The treatment members of the medical "family" should be able to recognize those individuals whose personality structure is sound enough to ride through these natural reactions On the other hand they should be alert to the excessive or protracted responses and inappropriate behavior which may indicate inability to cope with physical handicap This latter group of patients and their families should receive every effort of the entire treatment staff and much more than perfunctory assistance if disaster is to be avoided

These reactions to illness are indicated in different ways Most patients express hostility toward others the members of their family other patients in the ward and frequently the staff and the therapeutic regimen This hostility is usually verbalized except when an occasional patient is so severely involved that speech is impossible and he must resort to the most primitive activities such as voluntary soiling and wetting A few patients contain their hostility within themselves and only outwardly indicate its existence through marked passivity and failure to show improvement

Everyone concerned with the care of such patients should recognize that this is not a permanent nor a pathological state even though it is a trying one It is easier for the medical staff to cope with such behavior if they

THEORETICAL COMPONENTS OF BODY FUNCTION IN HEALTH



The bar graphs crudely illustrate the dynamic situation in which CAPACITY FOR PHYSIOLOGIC WORK is the maximum ability of the person to perform a particular function e g respiration circulation muscular contraction, etc DEMAND represents that proportion of the capacity which is utilized in the energy expenditure required by the particular activity

As a primary hypothesis it seems likely that an individual s capacity for physiological work of a particular kind normally exceeds any demands which are put upon it In the case of breathing quiet respirations involve minimal and most efficient energy expenditure for the work accomplished The amount of work and the cost in energy can increase tremendously upon demand In an emergency energy output can even temporarily exceed oxygen supply by virtue of anaerobic metabolism The range through which increasing work output extends can be considered the reserve for meeting ordinary demands or sudden extreme needs occasioned by unusual activity stress and disease

POST-ACUTE AND CONVALESCENT TREATMENT OF POLIOMYELITIS

IMPORTANT CONSIDERATIONS IN THE CONVALESCENT PHASE OF TREATMENT

The goal of convalescent care is to attain the most useful function of which the patient is capable * This is reached by safe scheduling in which the physical activities required by the treatment program are balanced against the patient s tolerance Practically the attainment of this delicate balance throughout the recovery period is the largest problem in rehabilitation

Positive prescription of treatment in convalescence is most difficult Treatment in the acute phase is naturally suggested by the vivid alterations in body function which rapidly develop at the onset In contrast the partial or complete recovery which occurs subsequently may take months or even years The gradual nature of recovery processes makes evaluation of the patient increasingly intricate and treatment needs less sharply defined Complications also tend to be insidious and obscure

Any realistic program places increasing physical demands upon the patient The muscular component is readily apparent but simultaneously demands are placed upon other body functions which are not so clear but which may be of crucial significance Recognition of these factors is implied in the caution of experienced clinicians to "avoid fatigue Fatigue is an unreliable guide to proper programing since it reflects not only a physiological compromise but in addition a poorly understood and relatively immeasurable psychological component

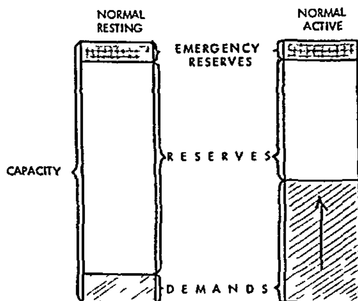
For these reasons a theoretical framework has been devised to define the principles which appear to be important clinical precepts for the safe conduct of the severely involved and are useful in the optimum management of the majority of the patients

Respirator patient experience has undoubtedly emphasized in the extreme the principles and the more reliable observations which bear upon this most complicated situation

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* Useful is not necessarily the most active function possible

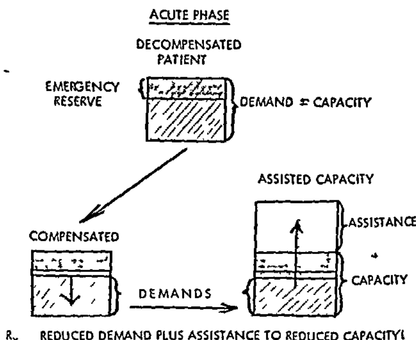
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THEORETICAL COMPONENTS OF BODY FUNCTION IN DISEASE



The insult of a disease such as poliomyelitis reduces many of the body's capacities e g respiratory muscle paralysis decreases breathing capacity When the reduction in capacity is severe the demands of basal activity may exceed the maximum effort which is possible In the face of unavoid able demands upon inadequate capacities immediate correction must be made to prevent irreversible damage and death There are three measures which are generally employed (1) Reduce demand to the most basal state which can be obtained (2) supplement or substitute for inadequate func tions where possible e g, artificial respiration (3) attempt to correct unsuitable or harmful body responses e g severe hypertension hypoten sion, etc These principles are easily demonstrated in the treatment of *severe respiratory impairment* and other vital *neuromuscular involvement* The decreased capacity of body functions such as circulation metabolism and even psychologic activity may be much less obvious

To some extent such considerations apply to most bodily activity in greater or lesser degrees depending upon the constitution of the person and the magnitude of the insult

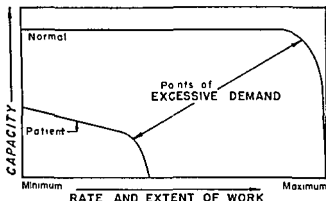
The bar graphs illustrate the role of reduced demand and assistance or substitution in the preservation of life sustaining capacity

THEORETICAL COMPONENTS OF BODY FUNCTION IN RECOVERY FROM DISEASE

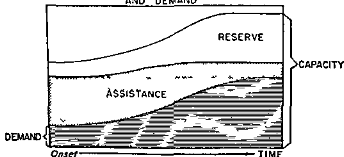
RECOVERY QUOTIENT

$$\frac{\text{Capacity} + \text{Assistance}}{\text{Demand}} > 1$$

WORK TOLERANCE



PATTERN OF RECOVERY GUIDING ASSISTANCE AND DEMAND



In contrast to the normal person a patient s tolerance to work demand is not only lower because of a reduced capacity in disease but as the extent and rate of work increase a further reduction may occur For this reason the point of excessive demand which represents emergency physiological compensation and a marked decline in capacity may be easily exceeded in the patient If recovery is to proceed without physiological compromise

the patient s capacity and the assistance which can be afforded him must always exceed the demands placed upon him The RECOVERY QUOTIENT expresses this relationship which is the guiding principle of convalescent care for the severe poliomyelitis patient *in virtually all of its phases* Partial recovery of capacity on the other hand depends upon the progressively increasing challenge of work which should be minimal at first then gradually increased to the point beyond which there is no further development of capacity In a similar fashion assistance can be gradually decreased and eliminated in some or retained in others in order to permit modest useful work output

PRINCIPLES OF CONVALESCENT CARE

Recognize decreased capacity for work of any kind
At first decrease the need for energy expenditure to the lowest possible level
Provide physiologic assistance where possible to prevent excessive or unavoidable demands from injuring the patient
Err on the side of excessive assistance since estimates of demand are usually too low
Provide and protect reserves by assistance in the phase in which increasing work is used to stimulate the development of additional capacity

Obviously these principles become increasingly important when the residual effects of the disease are more extensive They are realistic and practical considerations for the safe attainment of modest neuromuscular functional goals in the severely involved patient These goals are directly dependent upon the energy requirements of simple acts For such reasons complete independence from some form of artificial respiration in some instances may not represent the best goal All too often heroic efforts at completely unaided respiration may prevent the patient from performing other more useful and important activities such as feeding self help etc Likewise the patient s strong motivation for the high energy expenditure activity of walking may have to be redirected in a more realistic direction consistent with his capacity

For the less severely involved patient these principles point up the gradual nature of recovery of muscle function muscle hypertrophy which results from increasing usage and the value of initially protecting the patient against excessive activity Without question one cannot ignore the broad needs of the patient whose disease and recovery processes involve more than muscular contraction

GENERAL PLAN OF POST ACUTE AND CONVALESCENT TREATMENT

Convalescent Phase Management primarily by Physiatric and Orthopedic Services with close integration and understanding of aims by all personnel

- Prepare for Motion
  - Relieve pain
  - Release tightness
  - Support weakness
- Coordinate and strengthen
  - Muscle evaluation
  - Muscle re education
  - Stretching
  - Assistive and supportive apparatus
- Increase Function
  - *Functional testing*
  - Functional activity and training
- Reconstructive Surgery
  - Balance musculature
  - Stabilize joints
  - Release contractures
  - Prevent deformities
  - Correct existing deformities

Until time proves otherwise treatment is conservatively planned on the assumption that complete muscle return will occur The patient should be periodically evaluated from all aspects physiologically socially psychologically neuromuscularly vocationally for the purpose of increasing decreasing or continuing his program as indicated The rate will be determined by the patient s response without compromising his physiological reserves or his neuromusculo skeletal systems

The ultimate success of the program is determined by the organization s capacity for *indefinite follow up observation and care*

CAUSES OF MUSCULAR WEAKNESS IN POLIOMYELITIS

DIRECT VIRAL INVASION

MOTOR NERVE CELL

- Permanent destruction of the motor nerve cell with subsequent atrophy of denervated muscle fibers
- Temporary and reversible impairment of nerve cell function which leads to altered muscle activity

INTERNUNCIAL NERVE CELLS OF THE SPINAL CORD

- Permanent disruption of all but two neurone spinal reflex arcs interruption of the final pathway of descending tracts which synapse with internuncials and elimination of cross connections of segmental reflex arcs
- Reversible and temporary damage

SUPRASEGMENTAL NEURONES

- Generalized hyptonia of central origin as seen in encephalitic forms

INDIRECT CAUSES OF WEAKNESS

EARLY

- Reflex inhibition of muscular activity due to pain
- Impaired muscle cellular function from nutritional and metabolic disturbances e g alkalosis hypokalemia etc
- Hysteria associated with poliomyelitis

LATE

- Insufficient exercise as a result of immobilization
- Excessive activity or over stretching of a weakened muscle
- Persistent limitation of motion due to contractures and shortening
- Habitual positioning and muscular imbalances
- Persistent reflex inhibition of muscular activity as a result of prolonged and sustained activity of antagonistic musculature or alterations in the proprioceptive nervous mechanism of tendons and muscles which regulate reflex activity

The most frequent and unmodifiable cause of muscle weakness is the result of invasion of the nerve cell by the virus of poliomyelitis Persistent weakness is due to death of the motor nerve cell and subsequent muscle fiber atrophy When the destructive process is extensive enough to eliminate the majority of the motor units comprising a muscle flaccid paralysis with absent tendon reflexes is observed Clinical evaluation of this spinal cord process is inexact Apparently a considerable number of motor units can be inactivated before clinical evidence of weakness appears Grades of weakness cannot be directly related to the extent of motor nerve cell destruction

The other causes of weakness are intermingled and probably occur in various combinations They can contribute in various degrees to the acute symptoms and must account for some of the remarkable recoveries observed which clearly cannot be a result of reconstitution of the motor cell population Muscular weakness resulting from indirect causes may recover spontaneously or require proper therapeutic measures from onset for the preservation of muscle power

EVALUATION OF INDIVIDUAL MUSCLE STRENGTH BY THE USE OF MUSCLE ACTION, PALPATION, GRAVITY AND MANUAL RESISTANCE

USEFUL FOR

Diagnosis	Presence pattern and extent of muscle weakness
Prognosis	Area of involvement Rate of progression of weakness Magnitude of loss of muscle power Rate and extent of recovery

Treatment and its evaluation in

- Muscle re-education
- Assistive supports and splints
- Permitted functional activity
- Reconstructive surgery

GRADING (Lovett system—the basis for most present day grading)

100% Normal	Complete range of motion against gravity with full resistance (A normal muscle regardless of age build occupation etc has a resilient (springy) feeling when resistance is applied)
75% Good	Complete range of motion against gravity with moderate resistance (A GOOD muscle will play out when resistance is applied)
50% Fair	Complete range of motion against gravity
25% Poor	Complete range of motion with gravity elim inated
10% Trace	No motion of the part but contraction of the mus cle or tendon is felt
0% Zero	No motion or contraction present

Physicians will find it valuable to be familiar with general group muscle testing for diagnosis and planning the treatment program (See General Evaluation of Muscle Strength) but usually rely upon the skill of the physical therapist for a detailed muscle examination In the diagnostic and

acute stages of poliomyelitis a quick general evaluation of muscle strength is sufficient so that the patient is not unnecessarily exhausted Poliomyelitis especially in the stage of progression is characterized by asymmetrical weakness involving muscle groups around the same spinal segment

After the patient has been afebrile for 48 hours a detailed muscle test is in order It is recognized that muscles perform in groups and that their actions are overlapping Nevertheless no two muscles have exactly the same action and no motion can be performed normally without all of its muscular components With good knowledge of muscle function careful positioning and observation the strength of each muscle can be differentiated and a treatment program instituted

GENERAL EVALUATION OF MUSCLE STRENGTH

The following procedures may be done in five minutes or less for general detection of weakness in muscle groups Muscles will appear to be weak or flaccid if there is pain or shortening in the antagonist Range of motion should be checked passively so that an erroneous picture of weakness is not obtained

Resistance is given just to the point where the muscle gives A normal muscle—regardless of age weight etc—has a "spring back feeling while weak muscles play out with resistance

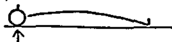
If the patient is unable to move the part into the desired position the muscles are probably weak, but not necessarily flaccid Assist the motion and ask if the patient can hold it Observation and palpation of muscle bellies and tendons is valuable throughout

COMPLETE CHECK IN THE SUPINE POSITION

STERNO CLEIDO MASTOIDS (and accessory neck flexors) and **ABDOMINALS** The patient raises the head and shoulders up from the bed and looks at the feet Resist the head and palpate the abdominals (Note this is often difficult or impossible with increased tonus of the erector spinae Abdominal strength can be estimated by palpation during forced expiration as in coughing or by resisting leg raising)



ERECTOR SPINAE (cervical thoracic and lumbar) Place your hand under the patient's head and have him hold down while you try to raise him up Patient should be able to hold the back rigid with muscles of 70% and above strength (Note this is not a very accurate test since most patients have "increased muscle tonus" in this group A more accurate measurement can be found with the patient in the prone position)

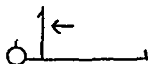


SHOULDER Have the patient raise the hand and arm and point to the ceiling Resist in four directions—flexion extension abduction and adduction

1 Flexion ANTERIOR DELTOID CORACOBRACHIALIS



2 Extension LATISSIMUS DORSI, TERES MAJOR, POST DELTOID



3 Abduction MIDDLE DELTOID, AND SCAPULAR ADDUCTORS (MIDDLE TRAPEZIUS, RHOMBOIDS)



4 Adduction PECTORALIS MAJOR



ELBOW Patient bends the elbow Resist in two directions and rotation

1 Flexion BICEPS BRACHII, BRACHIALIS, BRACHIORADIALIS



2 Extension TRICEPS BRACHII



3 Pronation PRONATOR TERES, PRONATOR QUADRATUS Patient turns the palm toward the feet resist in the opposite direction

4 Supination SUPINATOR BREVIS, BICEPS BRACHII Patient turns palm toward face resist in the opposite direction

WRIST AND FINGERS

1 Extension EXTENSOR CARPI RADIALIS AND ULNARIS EXTENSOR DIGITORUM COMMUNIS, EXTENSOR POLLICIS LONGUS AND BREVIS

Have the patient extend the wrist and spread the fingers Resist the fingers



2. Flexion LUMBRICALES, FLEXOR DIGITORUM SUBLIMUS FLEXOR DIGITORUM PROFUNDUS, FLEXOR CARPI RADIALIS AND ULNARIS

Place your fingers in the patient s hand have him close his fingers in a fist resist by trying to open the hand

THUMB

OPPONENS POLLICIS ABDUCTOR POLLICIS LONGUS AND BREVIS FLEXOR POLLICIS LONGUS AND BREVIS

Have the patient touch the tip of the thumb to the tip of the little finger Resist by pulling the thumb and little finger apart (Note for true opposition the thumb nail should be parallel to the palm)

HIP

Resist in four directions—flexion extension abduction and adduction

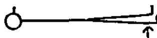
1 Flexion ILIOPSOAS SARTORIUS RECTUS FEMORIS

Have the patient raise the leg straight up from the bed. Resist toward the bed (Note if the patient can raise the leg the muscles are 50% or better)



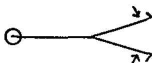
2 Extension GLUTEUS MAXIMUS HAMSTRINGS

Have the patient attempt to hold the leg on the bed while you try to lift it up (Note normally he should be able to hold it stiff and you should be able to lift him as a unit up to his upper back or head)



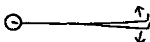
3 Abduction GLUTEUS MEDIUS AND MINIMUS TENSOR FASCIAE LATAE

Place the patient s legs in abduction have him hold them while you try to push them in This can be done well bilaterally



4 Adduction ADDUCTOR MAGNUS LONGUS BREVIS PECTINEUS

Have the patient try to hold the legs together while you pull the legs apart



KNEE

Support the thigh in 20 to 40 degrees of flexion Resist extension and flexion

1 QUADRICEPS FEMORIS—The patient extends the knee resist at the foot

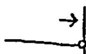


2 HAMSTRINGS—The patient bends the knee and you resist the motion



FOOT, ANKLE, AND TOES

1 Dorsi Flexion TIBIALIS ANTERIOR, EXTENSOR DIGITORUM LONGUS, EXTENSOR HALLUCIS LONGUS Have the patient dorsiflex the foot try to push it into plantar flexion



2 Plantar Flexion GASTROCNEMIUS AND SOLEUS The patient pushes the foot down try to push it into dorsi flexion (Note if this muscle gives because of weakness marked involvement is present.)



3 Inversion TIBIALIS POSTERIOR, TIBIALIS ANTERIOR Have the patient swing the foot down and in resist in the opposite direction

4 Eversion PERONEUS BREVIS AND LONGUS Have the patient swing the foot down and out resist by pushing the foot in

5 Toe Extension EXTENSOR DIGITORUM LONGUS AND BREVIS EXTENSOR HALLUCIS LONGUS The patient extends the toes —resist toward flexion

6 Toe Flexion FLEXOR DIGITORUM LONGUS AND BREVIS, LUMBRICALES, FLEXOR HALLUCIS LONGUS AND BREVIS The patient curls the toes and you try to open them

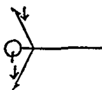
OTHER USEFUL CHECKS IF THE PATIENT CAN ASSUME POSITIONS

PRONE POSITION

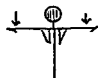
1 ERECTOR SPINAE (CERVICAL THORACIC AND LUMBAR), GLUTEUS MAXIMUS AND HAMSTRINGS Have the patient raise the head and shoulders from the bed and legs if possible Resist at the head and heels and check where the patient breaks (Note at least 50% muscles are needed to do this without resistance)



2 MIDDLE AND LOWER TRAPEZIUS RHOMBOIDS AND POSTERIOR DELTOID Arms in abduction—the patient keeps the head on the bed and raises the arms up (Note 50% or better muscles are needed to do this) Resist at the wrists



SITTING OR STANDING DELTOID, TRAPEZII, RHOMBOIDS Have the patient abduct both arms resist at the wrists and view from the back



STANDING

1 GLUTEUS MEDIUS The patient stands on one leg If the pelvis drops on the opposite side (positive Trendelenburg) or the trunk shifts to the same side there is marked weakness of the Gluteus Medius



2 GASTROCNEMIUS-SOLEUS

Have the patient stand on one leg and rise up on that toe There is marked weakness if he cannot do this



3 Have the patient squat down on the heels and rise to the standing position without using the hands Children and young adults can normally do this but if there is any weakness in the legs, particularly the QUADRICEPS, AND GASTROCNEMIUS SOLEUS, they will lose their balance or be unable to go all the way down

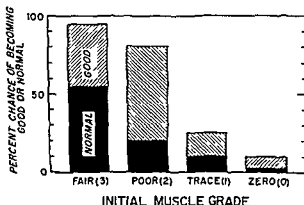


WALKING weakness or tightness of each individual muscle group in the lower extremities and trunk causes a particular type of gait Usually this is communicated to hip position Watch for dropping of the pelvis shifting of the trunk laterally anteriorly or posteriorly over the stance leg locking of the knee on stance slapping of the foot New polios do not walk in hip and knee flexion and it is also unusual for them to walk stiff legged

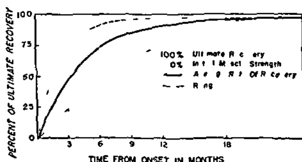
Weakness in the feet can be checked readily by having the patient walk on the toes (view from behind) and walk on the heels (view from the front)

RATE AND EXTENT OF MUSCLE RECOVERY

Per cent chance of severely involved muscles recovering to "Good" or "Normal" eventual strength [24, 25]



Rate of muscle recovery irrespective of the initial or final strength [25]



It is apparent that the pattern of recovery of muscle strength in paralytic patients who have had adequate treatment may include muscles which recover and those which do not A muscle which is "Zero" from onset and remains so three to six months may be classified as a non recoverable mus cle In spite of this flickers and traces of muscular activity often appear at a later time but are seldom of sufficient strength to become useful without the aid of elaborate assistive devices Such traces of movement in the upper extremities may make the patient more independent in self help activities

of eatıng, wrıtıng etc through the use of specıal assıstıve devıces In con trast trace strength ın the lower extremıtıes ıs ınsuffıcıent for weıght bear ıng and walkıng

Recoverıng muscles ıncrease ın strength at a defınıte rate ırrespectıve of the ınıtıal and eventual power Fıfty to seventy five per cent of the recovery occurs ın the first three to sıx months after onset wıth lıttle sıgnıfıcant ın crease ın strength occurrıng after one year The steps of the recovery curve may vary for the ındıvıdual patıent Infants, for example seem to recover slowly but often make exceptıonal ımprovement ın strength

On the other hand ımprovements ın the functıonal use of these muscles ın actıvıtıes such as eatıng, walkıng etc, wıll not necessarıly parallel the ıncrease ın test strength Through practıce ın developıng better coordına tıon and endurance, functıonal abılıtıes can ımprove ındefınıtely after stabı lızatıon of muscle strength has occurred

Muscles whıch show some power on first examınatıon wıll almost always ıncrease ın strength unless they are overworked, ın whıch case they may not ımprove or may decrease ın strength The ıncrease ın strength ıs varıable for the ındıvıdual patıent or ındıvıdual muscle but nonetheless a prognostıc pattern ıs present Muscles whıch are graded Good wıll usually return to a Normal grade (Thıs ıs not a pre ıllness Normal but merely a clınıcal test grade of Normal") A muscle graded "Poor plus (30% test strength) ınıtıally may not return to "Normal but ıt has an excellent chance of be comıng functıonally useful Muscles graded "Trace (10% test strength) and "Zero" have lıttle chance of attaınıng a functıonal grade (See figures above)

In evaluatıng the prognosıs for an ındıvıdual muscle ıt ıs useful to con sıder the status of other muscles ın the same spınal segment A Trace" muscle wıth "Zero" muscles ın the same segment has a poorer prognosıs than ıf the other muscles ın the segment are of Poor and "Faır classıfı catıons

The most ımportant value of these muscle recovery prognostıc guıdes lıes *ın orıentıng the patıent and famıly early ın the treatment program* toward reasonable expectatıons and safe functıonal goals and ın plannıng and carryıng out the most effectıve treatment program An ındıvıdualızed pro gram wıll go through preventıve and restoratıve phases perıods of adjust ment and stabılızatıon tımes of ıntensıve therapeutıc actıvıty and eventu ally requıre a follow up schedule for maıntenance The most ımportant consıderatıon ın arrangıng the treatment program ıs the tıme of the changes and the orıentatıon of the patıent as to the reasons for changes Treatment modıfıcatıons and expectatıons for ımprovement are dependent on the present strength of the ınvolved muscles the general state of health of the

patient his age the rate and extent of recovery which has already occurred, together with what may be predicted from the extent of paralysis

Re-evaluation of the treatment and activity program is necessary at regular intervals and is particularly important when the rate of recovery seems to decrease or there is no indication of progress This may indicate that the program is too strenuous the patient is over using a muscle group or the treatment recommendations are not being followed A plateau may mean that maximum recovery has been reached As indicated in the lower figure the crucial time for correct treatment schedules lies in the first nine months of the recovery period During this time it is quite easy to overwork the patient and inhibit development of potential strength or actually cause loss of strength If this situation is not corrected or has been permitted too long the chances of recovery are markedly diminished.

PROCEDURES USED TO INCREASE MUSCLE STRENGTH AND COORDINATION

MAXIMUM RECOVERY OF BALANCED MUSCULAR ACTIVITY REQUIRES CONTINUOUS ATTENTION

INITIALLY PROTECT AND COORDINATE, THEN STRENGTHEN

Protect Weak Muscles by Avoiding Continuous or Purposeless Activity
- Bed rest
- Support weak muscles from continuous stretch
- Limit physical activity

Utilize Splints Which Assist Function and Prevent Substitution (See Assistive and Supportive Apparatus Page 123)

Institute Muscle Re education
- Retrain proprioceptive mechanism"—awareness of the dynamic position of muscles joints and entire body members
- Increase muscle power
- Achieve and strengthen coordinate patterns of motion

Prevent Substitute Action of Strong Muscles for Weak Ones—Leading to Imbalance and Deformity

Do Not Over use Weakened Muscles (over use produces progressive incoordination—development of faulty motion patterns and loss of power)

LATER (3 to 9 months) SELECTIVELY STRENGTHEN APPROPRIATE MUSCLES BY HYPERTROPHY TO
- Compensate for muscular imbalance
- Obtain maximum strength for useful work or appropriate substitute activities
- Obtain maximum endurance in function

As pain and soreness subside passive range of motion is established Then a program of re education of the muscular system is started This consists of progressively increasing the work of the muscle by manual assistance changes in the amount of friction upon the part being moved increasing the work of the individual muscle against the effect of gravity and resistance or utilizing cortical patterns of motion to gain overflow from strong to weak muscles The patient is not allowed at any time to produce jerky

motions or utilize other than the desired muscle or muscles These principles are accomplished most effectively by the physical therapist Careful employment of auxiliary aids such as hydrotherapy sling suspension and counterbalancing weights may assist the physical therapist in attaining the desired end result

Many systems of muscle re-education have been developed and advocated Uniformly good results appear to be a consequence of meticulous attention to the details of a single method and utilization of its aspects in the proper degree at the indicated time and place by an experienced therapist

RANGE OF MOTION

PURPOSE	To minimize fibrosis and contracture in muscles tendons fascia and joints which occur from immobilization habitual position or muscle imbalance To maintain and increase the present range of motion
USE	When active motion of all joints cannot be per formed by the patient as in muscle paralysis or unconsciousness
PROCEDURE	Support the part firmly Move the part just short of the point of pain through its full range if possible Repeat each motion three to five times at least once daily

Range of motion need not be done as a complete and separate procedure once the routine is learned It can be accomplished on an extremity or joint at a time during routine care such as the bath taking of blood pressure and changing positions In acute polio the muscle bellies are sore and ten der For the patient s comfort he should be handled and moved at joints and bony prominences with the flat of the hand See Joint Range of Motion (pages 90 92) for specific motions

STRETCHING

PURPOSE To increase function and to prevent or minimize deforming factors

PROCEDURE

Precede stretching with heat when effective

Stabilize to prevent undesired motions

Use a short lever arm in order to apply force close to the axis of the joint and thereby control the motion

Gain relaxation of the antagonist by obtaining the patient s cooperation

Move the part towards its normal range of motion to the patient s tolerance (not the physical therapist s)

Encourage active participation on the part of the patient whenever possible

Avoid overstretching weak muscles

Evaluate the practical value of complete range of motion in flail shoulders trunk and hips

A stretching program must be carefully evaluated as to its objectives so that the best use of time and techniques produce the desired functional result

There should be no compromise in gaining normal range of motion in the iliopsoas and iliotibial bands or in maintaining symmetry of the back Even though it may be decided not to stretch the erector spinae anteriorly lateral flexion and rotation of the trunk must be kept symmetrical. Trunk musculature of good and normal strength must be stretched to normal range in all of its components particularly in children

In the severely involved patient normal range of motion is not always the desired end result in certain instances Flail shoulders should be stretched completely in rotation but only to 90 in flexion and abduction This is sufficient to allow dressing and the use of slings and feeders On the other hand supernormal range of motion may be needed in the lower extremities when they are to be used to replace non existent hand functions e g typing and telephoning with the feet

If stretching is utilized effectively it need not be a traumatic experience A psychological block to the whole treatment program may occur with overzealous stretching The initial time required in gaining the patient s cooperation and confidence is obviously justified by a superior end result

Prevention and dynamic positioning are often more effective and desirable than stretching to maintain or gain a range of motion

If fixed contractures have occurred, manual stretching and positioning may be ineffective and surgical release may be indicated with shortening of the iliotibial bands tendo achilles etc

ASSISTIVE AND SUPPORTIVE APPARATUS

PREVENTIVE SUPPORT IS MORE DESIRABLE THAN CORRECTIVE MEASURES

ACUTE PHASE Used to maintain normal skeletal alignment

Utilize readily fitted comfortable easily obtained temporary supports and splints

CONVALESCENT PHASE Used to assist function and to prevent deformity Utilize dynamic splints and braces The suitability of these splints must be reviewed periodically since changes replacements or elimination are dictated by improvement in function

Assist weak muscles in performing motions or to obtain mechanical advantage for functions e g the use of sling suspension springs and rubber bands corsets and opponens splints

Eliminate undesired motions which may lead to substitute action or deformities e g use crutches to maintain normal or near normal pattern of walking

Stabilize weak body members so that function may be gained e g long leg brace to maintain knee extension permitting ambulation

Maintain good normal skeletal alignment until maximum bony growth has been attained Contemplated surgical procedures will be more effective

CHRONIC PHASE Used to increase function endurance and to minimize deforming forces

Obviously the individual s age weight occupation activity interest and needs as well as the availability of suitable apparatus and its cost dictate the various types of assistive and supportive devices utilized

A close relationship must be maintained between the patient his apparatus and the physician always keeping in mind that the patient is ever changing in function and growth

Equip the patient with the lightest and smallest amount of indicated apparatus Weakness is not always an indication for bracing Deforming muscle imbalance is an indication for bracing Apparatus should never be so cumbersome as to interfere with the development of actual or potential function

INCREASING FUNCTIONAL ABILITY

EARLY

Teach normal patterns and actions, e g , use crutches to main tain normal relationship of parts in the walking pattern to stimulate further recovery and balanced action

Work below maximum tolerance of the patient

LATER (6 to 12 months) OVERDEVELOP RESIDUAL ABILI TIES TO SUBSTITUTE FOR LOST MOTIONS—INCREASE WORK DEMANDS

Increase proprioceptive awareness through repetitive practice

Increase strength of remaining useful muscle fibers by high resistive exercises

Develop skill in substitute actions e g , moving from wheel chair to bed using arms tying shoes with one hand

Utilize assistive devices where needed to increase function and endurance

Develop endurance by repetitive highly resistive exercises and skills to the point beyond which performance suffers

Utilize surgical procedures to restore motion stabilize and eliminate appliances

Useful functional achievement is the goal of all rehabilitation programs The patient should be tested to determine his independent ability to per form ordinary daily acts such as dressing brushing teeth, eating walking climbing stairs etc and a program for attainment should be outlined Goals are based on the muscular capabilities the physiological capacity the practical need for the activity and the patient s desire

Retraining and substitution of residual abilities is similar to the program of activity analysis and the development of skill and endurance used in the training program for the superior athlete

ORTHOPEDIC SURGERY

GENERAL CONSIDERATIONS IN POLIOMYELITIS

PREVENTION IS MORE DESIRABLE THAN CORRECTION!

AIMS

- Prevent deformities of bony structures—of primary importance for the growing child
- Restore or assist useful function
- Eliminate appliances and apparatus while maintaining function
- Correct deformities

EMPLOY EXTREMELY CAREFUL EVALUATION OF THE PATIENT IN ORDER TO INSURE THE EFFECTIVENESS OF SURGICAL PROCEDURES

- Effectiveness of surgical procedures depends as much upon the functional capacity to take advantage of the result as upon the perfection of the operation e g a probably successful opponens transplant may be contraindicated in the absence of extensor digitorum communis function
- The specific procedure used and the end result obtained depend upon patient cooperation and the adequacy of follow up care
- Utilize accurate estimations of bone age in planning surgical procedures
- Stabilization and fusion operations are performed to assist function increase stability correct associated deformities or eliminate the need for appliances
- Tendon transplants are used to substitute for a lost function or to redirect a deforming force
- Transplants for motors should use muscle which has at least 70% of normal strength
- Proper combinations of stabilization and transplants may achieve better function than either alone

These factors are presented to aid the physician in understanding the role of orthopedic surgery and to facilitate its effective employment at the most suitable time The Orthopedist must see the patient early and follow him periodically and in some instances the entire convalescent program is his responsibility

Early surgical intervention almost always is concerned with soft tissue surgery upon connective tissue and muscle when conservative measures such as reeducation stretching and splinting have failed to achieve maximum function or adequately minimize the effect of deforming forces In regard to the latter serious offenders include the iliotibial band Achilles tendon and abdominal muscles

Modern surgical skill and facilities may allow a more desirable outcome as a result of early intervention

PARALYTIC SCOLIOSIS

ETIOLOGY

Paralysis of the spinal musculature

CONTRIBUTORY CONDITIONS IN COMBINATION WITH THE ABOVE

Continued growth and development of the vertebral column after onset of paralyis

Pelvic tilt as a result of unequal leg length muscular weakness or contractures

Unilateral lower extremity foot knee or hip dysfunction

Unilateral upper extremity paralysis in association with spinal involvement

Unequal abdominal intercostal or diaphragmatic paralysis

Persistent faulty body positioning due to weight bearing especially sitting

TREATMENT

The purpose of treatment is the preservation of balanced trunk motion in physical activities

The tedious and long continued measures which prevent this vicious deformity are hard to maintain because results which preserve the trunk are not dramatic if successful

Corrective apparatus such as corsets casts braces and traction apparatus as well as supportive equipment such as crutches are often necessary for prolonged periods

Facilities needed for adequate treatment and follow up usually include physical medical or orthopedic surgical services and radiology

It is imperative to carefully observe the growing child with any paralytic involvement of the spinal musculature at regular intervals The preventive measures which will forestall severe deformity resulting in respiratory and circulatory embarrassment are successful only if started early

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Paralytic scoliosis refers to the pathological curvature of the vertebral column as a result of paralysis of the spinal musculature Its pathogenesis is a controversial subject Nonetheless, proper preventive measures have greatly reduced the development of serious deformity

The treatment is specialized and requires a dedicated orthopedist or physiatrist The details are beyond the scope of this page However the factors mentioned are of sufficient general importance so that everyone concerned with the care of the patient must be alert to them and work with the physician directing the selected specific treatment Whether special corsets, partial body casts or other measures are employed the family must be reassured continually that these measures are essential because failure must be avoided at all costs and a good program produces little visible results to them if it is successful

PRINCIPLES OF ANESTHESIA FOR PATIENTS WITH POLIOMYELITIS

PREOPERATIVE

Utilize premedication with minimal dosage of barbiturates and atropine

Anticipate the accumulation of excessive secretions in any patient with a history of bulbar involvement

Anticipate the tachycardia labile blood pressure and poor compensatory vasomotor mechanisms of the respiratory patient Be prepared to treat hypotension with vasopressors such as Levofed® (See page 56)

Perform a "cut down" for intravenous fluids and whole blood in patients who are to have extensive procedures

OPERATIVE

Muscle relaxation is rarely required for the extensively paralyzed patient. Light general anesthesia is usually adequate Most anesthetic problems are concerned with airway and controlled ventilation

Local anesthesia is the anesthetic of choice for minor procedures and Caesarean sections when respiration is normal For major procedures endotracheal general anesthesia must be used to insure control and adequacy of ventilation

Spinal anesthesia is contraindicated in acute poliomyelitis and probably also in chronic poliomyelitis especially for prolonged procedures

Regional anesthesia is rarely adequate for the required surgical procedures It also carries the risk of pneumothorax in brachial block or thoracic paravertebral block.

Avoid intravenous agents which affect respiration (e g barbiturates opiates and muscle relaxants) Use inhalation agents which can be recovered from the body and thus permit prompt recovery from anesthesia at the end of the operation (e g nitrous-oxide ethylene cyclopropane) Cyclopropane is the agent of choice for most procedures

Empty the stomach after endotracheal intubation or at the end of the operation to remove air inadvertently forced in during positive pressure respiration Remove accumulated gastric

secretions in order to decrease the risk of vomiting and aspiration

POST OPERATIVE

Utilize smallest effective dosages of post-operative analgesics
Resume preoperative program promptly
Partially weaned respiratory patients require several days of tank respiration in the recovery period
Control gastro intestinal distention

The conditions requiring anesthesia commonly associated with poliomyelitis include pregnancy (vaginal delivery rarely Caesarean section), renal disease (diagnostic studies such as cystoscopy and major surgery such as pyelolithotomy or nephrectomy) and orthopedic surgical procedures Non respiratory patients are managed in much the same fashion as normal patients with attention to the principles outlined

Respiratory patients should be transported to surgery in the tank respirator The engineering department should lay a special power cable attached to a protected power supply Use the tracheotomy if present for controlled artificial respiration and avoid intubation of the upper airway For those patients without a tracheotomy use of mask artificial respiration or the chest abdomen cuirass respirator will permit transfer from the tank to the operating table Intubation is then performed with a cuffed endo tracheal tube under either topical or cyclopropane anesthesia Controlled or assisted respiration is necessary thereafter Transfer the respirator patient back to the ward in a tank respirator

Generally with proper preparation and coordination major thoracic and abdominal surgery can be carried out on the most severely involved poliomyelitis patient

PREVENTIVE MEASURES AND TREATMENT FOR NEPHROLITHIASIS

PREDISPOSING FACTORS

Bony demineralization leading to hypercalcuria oliguria infection of the urinary tract urinary stasis and constitutional factors In alkaline urines most stones are calcium phosphates or oxalates

PREVENTIVE MEASURES (See pages 75 135 and 136)

Maintain urinary dilution with large oral fluid intake to obtain urine specific gravity of 1 010 to 1 020 Three to four liters of oral fluid may be necessary daily in adults

Minimize dietary calcium intake and avoid enriched milk and supplementary vitamin preparations containing Vitamin D

Utilize serial urinalysis and urine cultures to permit effective treatment of infections should they occur

Detect radio opaque stones with serial abdominal plane film radiography

Urinary solubility of calcium may be increased by prophylactic medication with Aspirin in dosages of 10 grains three times a day (Adolescent and adult dosage)

Include early mobilization in the therapeutic regimen with introduction of early physical therapy frequent changes in body position and resume upright posture by means of the standing bed or tilt table

COMPLICATIONS

Uretero pelvic and ureteral obstruction by stones and sand This condition may be signaled by dull flank or abdominal pain unexplained abdominal distention and vomiting or intermittent colic Evidence for infection may accompany or follow obstruction and includes microscopic hematuria pyuria fever and polymorphonuclear leucocytosis

ACUTE renal shutdown is a sequela of persistent urinary tract obstruction

TREATMENT

Intravenous pyelograms are useful to indicate the functional status of the kidney and establish the site of obstruction

secretions in order to decrease the risk of vomiting and aspiration

POST OPERATIVE

Utilize smallest effective dosages of post-operative analgesics

Resume preoperative program promptly

Partially weaned respiratory patients require several days of tank respiration in the recovery period

Control gastro intestinal distention

The conditions requiring anesthesia commonly associated with poliomyelitis include pregnancy (vaginal delivery rarely Caesarean section) renal disease (diagnostic studies such as cystoscopy and major surgery such as pyelolithotomy or nephrectomy) and orthopedic surgical procedures Non respiratory patients are managed in much the same fashion as normal patients with attention to the principles outlined

Respiratory patients should be transported to surgery in the tank respirator The engineering department should lay a special power cable attached to a protected power supply Use the tracheotomy if present for controlled artificial respiration and avoid intubation of the upper airway For those patients without a tracheotomy use of mask artificial respiration or the chest abdomen cuirass respirator will permit transfer from the tank to the operating table Intubation is then performed with a cuffed endotracheal tube under either topical or cyclopropane anesthesia Controlled or assisted respiration is necessary thereafter Transfer the respirator patient back to the ward in a tank respirator

Generally with proper preparation and coordination major thoracic and abdominal surgery can be carried out on the most severely involved poliomyelitis patient

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Instrumentation may be necessary to dislodge stones or remove them when spontaneous passage does not occur
Early indwelling ureteral catheterization by passing the stone and permitting pelvic drainage and irrigation may be necessary to prevent renal shutdown
Surgical intervention is indicated if instrumentation fails and renal shutdown persists beyond twenty four hours in most instances
ALWAYS retrench respiratory schedule in respirator patients
Use whole blood transfusions if hemoglobin is less than 11 12 gms
Specific antibiotic or chemotherapy is usually needed for infection

The most important consideration in this problem is the prevention of stones resulting from the inevitable hypercalcuria The most effective preventive measure appears to be the maintenance of urinary calcium dilution with forced oral fluid intake Prevention of secondary urinary tract infection is next in importance Infection is often the sequel of long standing urethral catheterization This can be minimized if removal of the catheter is begun within the first two weeks of illness Establishment of good general nutrition active physical therapy regimens and mobilization with early resumption of the upright position are also necessary

In some severely immobilized quadriplegic patients preventive measures may be inadequate or impossible to obtain In such patients who also have respiratory involvement these intercurrent complications severely interfere with the rehabilitation program The physician should always be alert to their development and retrenchment in the breathing schedule must be carried out should they occur

In the experience of the Center antibiotic and chemotherapeutic agents indicated by culture of gram negative bacilli in the urine and *in vitro* sensitivity tests include Chloromycetin® and Furadantin® Suitable dosages employed in the adolescent and adult age range are

1 Chloromycetin®— 25 grams four times daily
2 Furadantin®—50 mgm four times daily

® Chloromycetin is the brand name for chloramphenicol and is made available by Parke Davis & Company Detroit, Mich
® Furadantin is the brand name for nitrofurantoin, N N R and is made available by Eaton Laboratories Norwich, New York

METABOLIC PROBLEMS IN THE POST ACUTE PHASE OF POLIOMYELITIS

NUTRITIONAL DISTURBANCES

The severely paralyzed and immobilized patient is prone to malnutrition because of inadequate caloric intake in the critical acute phase and faulty diet composition in the early post acute stages

Tube feeding may be needed The child especially may need tube feeding because of anorexia Any patient may develop severe anorexia with emotional disturbances which are sequelae of serious illness

Obesity may be a problem in late convalescence because of inactivity and excessive caloric intake A reducing diet is indicated

Subcutaneous edema associated with severe protein depletion *must not be mistaken for body fat*

Patients with severe malnutrition leading to a marasmic state who have needed prolonged parenteral feeding tend to develop gastrointestinal intolerance to voluminous oral feedings and dietary fat.

Reconstitution depends upon tedious and gradual resumption of both volume and caloric content of oral intake

MUSCLE WASTING AND WEIGHT LOSS

Severe muscular paralysis may be accompanied by body weight losses of from 10 to 40% of pre-illness weight

Weight loss is unavoidable and requires no treatment except to consider that "ideal" post illness weight is less than pre-illness weight and caloric requirements are proportionately reduced

Muscle is the largest single mass of metabolizing body tissue Severe extensive paralysis drastically reduces the muscle mass and body weight The resulting alterations in relative body composition make the severely paralyzed patient no longer comparable to the normal individual

While the basal needs of the patient with extensive paralysis are normal energy expenditure due to activity may be minimal to normal A caloric intake of 20 to 30% above estimated basal requirements appears to be adequate for maintenance of nutrition Obviously this depends upon the extent of the patient s functional loss and the consequent energy expenditures in active rehabilitation

Obesity may be a handicap to the patient since it increases energy expenditure in functional activities In general clinical examination and frequent weighing can be used to detect weight gain due to obesity This should not be confused with weight gain which may be associated with return of muscle mass

METABOLIC PROBLEMS IN THE POST ACUTE PHASE OF POLIOMYELITIS

HYPERCALCURIA AND HYPERCALCEMIA

- Hypercalcuria appears to be an invariable accomplice of paralytic poliomyelitis within the first few weeks of illness It may be of greatest intensity in the completely immobilized respirator patient or the severely paralyzed adolescent
- Hypercalcemia in excess of 14 to 15 mgm % concentration is dangerous Impairment of cardiac conduction renal damage from calcinosis and disturbances of the mental state may result
- Oral fluid intake should be forced to 3 to 4 liters per day in the adult patient so that urinary dilution of the excreted calcium is maintained below a concentration of 15 mgm %
- Moderate dietary restriction of high calcium intake should be accomplished Avoid milk feedings ice cream and foodstuffs rich in calcium
- Do not add vitamin D to the diet or use vitamin D enriched milk products
- Dehydration should be avoided
- Acidosis should be prevented since this increases the serum concentration of ionized calcium responsible for the damage Mild alkalosis (arterial pH of 7.45 to 7.55) which is observed frequently in the respirator patient may be beneficial
- Standing active physical therapy programs and use of tilt tables should be utilized although they may be of indeterminate value

IMPAIRED RENAL FUNCTION

- Renal disturbances include failure of urinary concentration during urine concentration test elevated urea nitrogen and calcium together with arterial hypertension
- Large obligatory urine losses of body water may occur and must be corrected by fluid intake
- Renal infection is a frequent sequelae of long standing catheterization and should be treated promptly (See page 132)
- Mobilization of the patient and early resumption of the upright posture favorably influences drainage of the urinary tract
- Arterial hypertension should always be treated promptly since it usually leads to further renal functional impairment *

As muscle pull and activity are denied through paralysis the production of new osteoid tissue by the skeleton decreases and a negative nitrogen balance results With the cessation of osteoid formation the absorbed calcium is not needed In addition, normal osteolytic processes continue and make more calcium available for excretion These two processes as well as other ill defined biochemical factors, combine to give severe hypercalcuria and hypercalcemia When hypercalcuria continues altered renal function may lead to failure of normal water and salt conservation by the kidney Concentration tests reveal urine specific gravities of 1 014 to 1 018 in the presence of clinical evidence of dehydration

Rigorous dietary calcium restriction is difficult to maintain because appropriate diets are notably unpalatable This factor alone does not appear to prevent hypercalcuria Maintenance of large oral fluid intake seems to be most crucial especially to minimize stone formation

Prophylaxis against renal damage is the keynote in the preservation of renal function This should include the treatment of infection and the control of hypertension with the hypotensive drugs such as extracts of Rauwolfia serpentina and the hydralazine derivatives such as Apresoline®

Although these problems are uncommon and develop mostly in the exceptional patient with extensive muscular paralysis or severe chronic illness the clinician should be able to anticipate and treat such complications

DOSAGE SCHEDULES FOR HYPERTENSION encountered in the chronic stage of severe poliomyelitis

A Plan of Treatment

In general the best results are obtained by early treatment of hypertension with conservative drugs and dosage schedules Hypertension may accompany the insidious and progressive respiratory insufficiency which can develop with very rapid respiratory weaning programs and excessive physical activity Patients with limited respiratory reserve who have tolerance to several hours of unassisted breathing time seem particularly vulnerable to this complication

Rauwolfia serpentina preparations or extracts may be used early whenever the systolic blood pressure is observed to be consistently elevated to levels greater than 150 mm of mercury in children and adults or when the diastolic pressure is found to be 90 95 mm of mercury or over in children and 100 mm of mercury or over in adolescents and adults Also tachycardia is observed frequently

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® Apresoline is the brand name of a hydralazine hydrochloride compound in 10 25 and 50 mgm. tablets made available by the Ciba Pharmaceutical Company Summit, New Jersey

Satisfactory dosage ranges are given for the following preparations any single one of which may be used

1 Rauloid®—two 2 0 mgm tablets daily for 1 week then one tablet per day on retiring (Adolescents and adults)
2 Raudixin®—two to four 50 mgm tablets daily for 1 week with gradual reduction to one tablet daily (Adults)
3 Serpasil®—one 0 25 mgm tablet daily (Adults)

Approximately one half of the foregoing doses may be used for children 10 to 15 years of age The development of hypertension has not been observed in younger children

B If severe hypertension with encephalopathy and papilledema has developed without prior recognition Apresoline® may be added to Rauwolfia preparations after 3 to 4 days of treatment with the latter Hypertensive crises may be treated with parenteral preparations of Serpasil in the manner described on page 55 Thereafter oral treatment is continued

1 Apresoline®—one 25 mgm tablet twice a day for 7 to 21 days in adults

C In general other hypotensive agents such as the hexamethonium derivatives are contraindicated

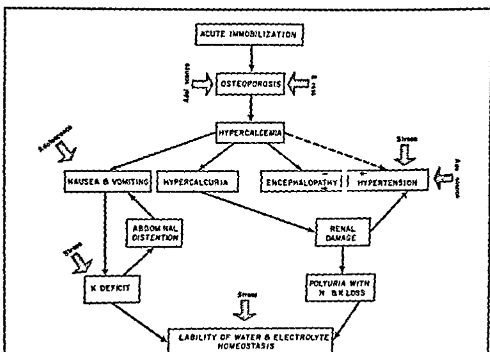
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® Rauloid is the brand name of a purified preparation of Rauwolfia serpentina made available in 2 mgm. tablets by Riker Laboratories Los Angeles California

® Raudixin is the brand name of a whole root preparation of Rauwolfia serpentina made available in 50 and 100 mgm tablets by E R Squibb New York

® Serpasil is the brand name of an alkaloid of Rauwolfia serpentina made available in 0 1 0 25 and 1 0 mgm tablets by Ciba Pharmaceutical Company Summit, New Jersey

IMMOBILIZATION SYNDROME OF THE ADOLESCENT PATIENT



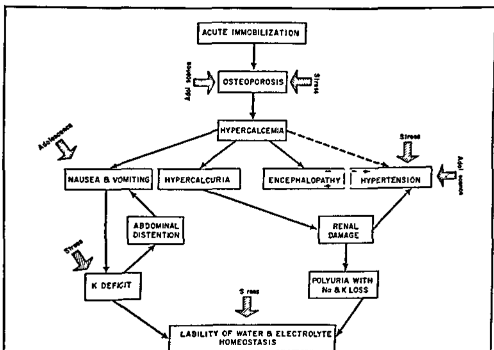
- The immobilization syndrome usually develops after the first 3 months of illness and is characterized by
  - Severe muscle wasting and body weight loss
  - Hypercalcuria and hypercalcemia
  - Gastro intestinal disturbances such as gastric distention and ileus with intolerance to oral fluids and food anorexia nau sea and vomiting
  - Arterial hypertension of moderate to severe degree
  - Mental depression and irritability
  - Fluid and electrolyte disturbances with labile water balance hypokalemia and therapy resistant body potassium deficits
  - Disturbances of renal function with elevated blood urea nitro gen reduction in the ability to concentrate urine and con serve body water reversal of the urinary sodium and potassium ratio with increased potassium losses
  - Evidence of adreno-cortical alarm reaction with seborrhea acne hirsutism and elevated urinary 17 keto-steroid excretion

This syndrome while apparently a reversible condition leads to severe problems in fluid and electrolyte management It is uncommon having been observed in only 8 instances in over 250 severely paralyzed respiratory patients All of the patients with this condition were in the phase of rapid growth at the time of onset of acute poliomyelitis They uniformly presented severe muscular paralysis and body weight loss which averaged 15 to 40% of pre illness weight All of the patients had histories of unusually severe fatigue from either excessive treatment programs or unrecognized respiratory insufficiency as a consequence of rapid weaning

Attention to their poor general condition was usually demanded by their precarious fluid and electrolyte economy since mild episodes of gastro-intestinal distress usually produced severe gastric distension ileus vomiting and dehydration Hypertension was a prominent condition as well as hypercalcuria and hypercalcemia in the presence of copious and dilute urine which could not be concentrated with thirsting Hypokalemia was usually found during episodes of dehydration and clinical and ECG evidence of myocardial impairment was observed The patients were resistant to potassium replacement therapy with reversal of the ratio of urinary excretion of sodium and potassium Renal hemodynamic studies indicated altered renal function which included reduction in glomerular filtration blood flow and vascular resistance

Although it is uncommon this syndrome is elaborated because one or more aspects of the condition are not infrequently observed in the severely paralyzed patient of any age Therefore the clinician should pay particular attention to the severely paralyzed respiratory patient in order to recognize incipient renal disturbances characterized by failure of urinary concentration Considerable credence should be given to the development of hypertension as a symptom in the post acute phase of illness particularly in association with hypercalcuria and hypercalcemia Treatment with anti hypertensive agents is both effective and desirable Of special importance is the ease with which the severely paralyzed patient may develop evidence of adreno-cortical stress responses which complicate the active respiratory and muscular rehabilitation program

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IMPORTANT METHODS FOR INCREASING THE EFFECTIVENESS OF SPONTANEOUS BREATHING

OBJECTIVES

- Sufficient pulmonary ventilation and endurance for unassisted breathing and the requirements of useful physical activity
- Respiratory reserves to meet the adjustments of breathing which accompany infection and respiratory complications
- Sufficient inspiratory volume and rhythmic expiratory control for speech
- Sufficient inspiratory and expiratory ability for coughing

METHODS

- Progressive respiratory weaning and increasing physical activity scheduled to avoid compromise from excessive fatigue and stress
- Early introduction and progressive use of auxiliary respiratory devices such as the cuirass respirator and rocking bed to forestall dependence upon the tank respirator and to encourage partial use of remaining respiratory muscles
- Respiratory muscle re-education
- Careful positioning of the body which is individualized depending on the pattern and extent of respiratory muscular paralysis and the measured effect on the vital capacity and minute volume of breathing
- Supplementing the effectiveness of residual respiratory muscles through splinting and corseting of the thorax and abdomen
- Development of proficiency in artificial and manual coughing
- Use of glossopharyngeal breathing

The progressive challenge of the respiratory muscles through graded usage is one of the most effective methods of increasing spontaneous breathing. This is accomplished with avoidance of muscular fatigue through the employment of auxiliary respiratory devices which are less effective than the tank respirator. A carefully regulated respiratory and activity schedule is essential (see pages 146 and 153). It should be combined with training of the patient in knowledge about the use of the remaining respiratory muscles. As in extremity musculature continuous use of weakened respiratory muscles at or near maximum ability causes them to *lose rather* than gain strength. When this is avoided many patients will achieve improvement in

muscle power and endurance so that they can ultimately breathe without assistance

It is extremely important to gain and maintain chest mobility in order to increase the efficiency of the remaining respiratory muscular movement

Respiratory muscle re-education in patients with low vital capacities (adults below 1500 ml) is most valuable in aiding the patient to become aware of the muscles and their effective use in breathing At first pursuit of these respiratory exercises with the intent of only strengthening them is of little value and unnecessarily fatiguing in the presence of markedly reduced vital capacities When the patient recovers to the degree that he no longer requires mechanical breathing assistance and his daily activities are not of a sufficient intensity to require his maximal breathing ability the use of breathing exercises for increasing strength should be encouraged

The patient whose spontaneous breathing is patterned after the equal inspiratory expiratory cycle of the respirator may need assistance in relearning to take quicker deeper inspirations and longer expirations for more normal speech Some patients develop undesirable facial and head movements as counterparts of respiratory activity These need to be minimized or altered for a more desirable appearance Reading aloud singing rhythmic verse and tape recording the voice are very useful in improving the rhythm volume and control of speech

BEGINNING WEANING FROM RESPIRATORY ASSISTANCE OF THE IMMEDIATE POST ACUTE PATIENT

ESTABLISH CONFIDENCE IN THE PATIENT AND FAMILY DURING THE ACUTE STAGE

Absolute familiarity with equipment by the entire staff to avoid apprehension due to accidents
Avoid having patient or family dictating treatment

PRELIMINARY POST ACUTE EVALUATION

Tidal volumes in the tank respirator
Vital capacity if possible
Observe breathing muscles for pattern of involvement (See pages 147 149)
Electrocardiogram
Frequent blood pressure and pulse
Complete blood count
Muscle test

TREATMENT FOR THE FIRST TWO WEEKS

Establish hospital routine and eliminate special privileges for patient and family
Discontinue oxygen therapy
Reset pressure and rate of tank respirator to the lowered needs of convalescence to avoid hyperventilation
Set and maintain daily breathing schedule
- Introduce chest abdomen cuirass respirator twice daily beginning with fifteen minute periods and increasing to one half to one hour
- Breathing alone three times a day IF vital capacity value is more than one half of the predicted tidal volume required by the patient (If this is the case only three to five minutes should be allowed If vital capacity is more periods may be up to but not exceed one half hour)

Bath during a m and physical therapy during p m cuirass times
Remove urethral catheter
Remove tracheotomy tube

After becoming accustomed to the cuirass respirator and short periods of breathing alone there is no danger of the patient becoming addicted to the tank respirator Hereafter there is no advantage to progressing the patient rapidly Err on the conservative side

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There is no substitute for clinical judgment for optimum care Observation of the patient s general appearance appetite attitudes cooperation signs of fatigue and needs for rest should be made All of the above with a consideration of the patient s feelings staff observation of his attitudes and objective tests should be used in determining the pacing of the patient s entire program

It is recognized that even with these guides the patient may be advanced too rapidly Breathing aid should be increased and activity decreased until the patient becomes stable in his various responses Then the program should be gradually progressed again.

Intercurrent complications infections etc always require retrenching in the direction of increased respiratory assistance

METHODS OF EVALUATING THE RESPIRATORY PATIENT FOR THE PROGRESSIVE WEANING AND REHABILITATION PROGRAM

RE EVALUATION OF THE PHYSIOLOGICAL RESERVES WITH REPETITION AT LEAST MONTHLY THEREAFTER

FACTORS USED IN DETERMINING PROGRAM

Vital capacity value Its magnitude relation to tidal volume needed for breathing and breathing muscles used rate of increase appearance of a decrease appearance of plateaus or sudden changes variation between horizontal and sitting values (with and without abdominal support—corsets or splints) (See pages 147-149)

Maximum breathing capacity values Which indicate increase decrease and dissociation from vital capacity values Relatively low values may indicate reduced endurance

Tidal volume *In tank and cuirass respirator* to determine adequacy of ventilation in different devices and for avoidance of hyperventilation

Fluoroscopic observation Use of breathing muscles pulmonary aeration pulmonary complications and cardiac silhouette (if patient can breathe alone for 5 minutes) Observe function of the diaphragm

Complete blood count For appearance of anemia or polycythemia due to hypoxia

Electrocardiogram Heart rate rhythm (especially nodal rhythm intermittent nodal rhythm or escaped beats) shortening of P R interval increase in width of P and QRS prolongation of Q T time presence or absence of S T segment elevation or depression development of right axis preponderance (clockwise rotation)

Blood pressure and pulse (For stability of values in 2 day studies) for pattern of mean values presence of tachycardia and hypertension hypotension and vaso motor collapse in the upright position and relationship of increasing physical activity to the foregoing (See page 160)

Blood chemistries and urinalysis For evaluation of adequacy of renal function

Complications of any variety influence capacity for unassisted breathing

THE INFLUENCE OF RESPIRATORY MUSCLE RESIDUALS AND BODY POSITION UPON SPONTANEOUS BREATHING

DIAPHRAGM

- The primary muscle of inspiration which is most effectively used in the supine position
- Paralysis of the diaphragm is shown by a fall of the abdomen on inspiration in the supine
- The starting position of the diaphragm is lowered in the sitting and standing positions so there is relatively less volume change of the thorax produced for a given amount of diaphragm movement This is pronounced if the abdominal muscles are weak, the abdominal wall sags and the viscera drop
- Marked paradoxical depression of the chest occurs in infants and children with normal diaphragms and weak or absent intercostals and abdominal muscles Inadequate ventilation of the upper chest occurs and an eventual rib cage retraction deformity may develop with growth

INTERCOSTALS

- Participate in inspiration by increasing the anterior posterior and lateral diameters of the chest
- Intercostals may be involved segmentally and unequally
- Used as primary respiratory muscles they are most effective in the sitting position Patients with intact intercostals and abdominal muscles but without diaphragms combine inspiration with forced (active) expiration Usually they breathe best in the sitting or standing positions with the back supported

ACCESSORY NECK MUSCLES

- Raise the rib cage as a unit and thereby increase the chest volume and produce inspiration
- Most effectively used in the upright position if the patient can throw his head back or has it fixed to gain a stronger lift Expiration is the result of relaxation and the action of gravity in returning the chest to a position of slight expiration
- Useful for supplementing other inspiratory muscles for a maximum inspiration but they should not be used by themselves

PROGRESSIVE REHABILITATION OF THE CONVALESCENT RESPIRATOR PATIENT

A schedule is unchanged for at least one to two weeks so that adequate observation can be made Patient and nursing staff should not alter the schedule

Gradual weaning from the tank respirator during the day depends upon early progressive use of less effective breathing aids

- Introduce the rocking bed for brief periods
- Increase the cuirass respirator time
- Increase breathing alone time IF breathing muscles and physiological reserves permit

Gradually increase the variety and extent of activity using the cuirass respirator during such activities (*Physical and Occupational Therapy Progression in Respiratory Polio*)

Evaluate the patient for sitting and performing functional activities without using breathing aids Start with the reclining chair and evaluate responses to the upright position Gradually assume full upright position

Change to cuirass or rocking bed at night if possible starting with *1 night a week if tolerated increase to 2 etc*

If elimination of respiratory aid at night is to be considered it should be done 1 night a week and then 2 and so on

Carefully consider the physiological reserves and the practicality of walking before attempting such physical effort Walking should not be considered if the vital capacity is below 800 cc in an adult

Use breathing aid at night and/or for rest periods in order to conserve energy for increased activity during the day

Intercurrent infections (even if infection appears mild)

- Increase breathing aid and discontinue activity
- Very gradually reassume former program

This is a continuous slow process over weeks and months each change *followed by a period of observation Only one variable is changed at a* time so that the breathing schedule is increased while activity is held constant or vice versa Sacrifice weaning speed if necessary to allow neuromuscular rehabilitation to proceed concomitantly It is obviously more desirable to have a well adjusted functional clear thinking individual using breathing help than to have a chronically underventilated tired stressed and irritable patient who breathes unaided

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for prolonged spontaneous breathing as the volume produced and the endurance of the muscles is usually not of sufficient level to permit activity These muscles are not used involuntarily during sleep

ABDOMINAL MUSCLES

Required primarily for forced expiration as in coughing

In the sitting and standing positions, the abdominal musculature maintains the viscera in position and establishes a more favorable position of the diaphragm for its descent with contraction than would be the case with visceroptosis

Can be used as a primary breathing muscle by virtue of active expiratory breathing with passive chest recoil promoting inspiration

COMBINATIONS

Patients with combinations of residual muscular function in different areas of the thorax (e g right intercostals left diaphragm) seem to achieve more effective ventilation for the same vital capacity than if the muscles are restricted to one area (e g right intercostals right diaphragm)

Abdominal pressurized belts can elevate the flaccid diaphragm as an active expiratory effort in the semi upright position and utilize the gravity descent of the abdominal viscera as a passive inspiratory effort

Due to individual differences in the pattern and extent of respiratory muscles paralysis only general guides can be followed for effective positioning corseting and sitting The vital capacity drops very slightly in the normal individual between the supine and sitting positions although the residual volume and expiratory reserve change in relative size This may be significant when all active expiratory reserve is gone as is most often the case in poliomyelitis Most respiratory patients experience a twenty per cent drop in vital capacity when upright This change in a vital capacity already markedly reduced may result in insufficient ventilation in the sitting position A few patients however may increase their vital capacity when sitting

Muscular endurance seems to be a separate function from the measurement of maximum effort so the vital capacity does not uniformly predict the patient s tolerance to unassisted breathing

A low thoracic lumbar corset usually aids ventilation in the sitting position and seldom if ever hinders it The corset is individually designed and fitted with firm support at the line of the pelvis Four steel stays are used in the back with one to one and one fourth inches between the middle stays The length of the corset is measured in the sitting position to extend from the buttocks at the table surface to just below the scapulae in the back and to the xiphoid process in the front It is strapped in front to permit sitting It is pulled in firmly at the base and the top buckles are kept loose to permit expansion of the rib cage Back braces do not aid spontaneous breathing nearly so much as the properly fitted corset

Infants with strong diaphragms who are lacking in intercostals and abdominals have been shown to ventilate better with a thoracic splint [29] This chest corset extends up to the level of the axillae but has the entire abdominal area cut out Steel stays are used in the back and are bent to place the spine in hyperextension In addition steel stays are placed on each side running around at right angles to the line of the false ribs The stays are molded so that the corset fits snugly on the lateral margin of the chest It is laced in front and forces the rib cage against inward retraction A space of an inch or so is left under the fastenings in front over the lower half of the sternum In this way the rib cage will still be allowed to expand in a forward (anterior) direction upon diaphragmatic descent

Flexion of the neck and back and adduction of the scapulae often occurs in a soft sagging bed and in the propped up semi upright position This places the chest in the position of expiration The breathing ability is reduced in most patients so positioned The breathing effectiveness will be increased in some through the use of a firm bed and interscapular pillows

The exact use of the muscles and mechanics of breathing may be controversial but the observations on the general use of muscles of breathing and the effect of apparatus and position are practical ones The actual measurement of the effect of body positioning, apparatus and activity on the vital capacity and ventilation of each individual is of paramount importance

for prolonged spontaneous breathing as the volume produced and the endurance of the muscles is usually not of sufficient level to permit activity These muscles are not used involuntarily during sleep

ABDOMINAL MUSCLES

Required primarily for forced expiration as in coughing

In the sitting and standing positions, the abdominal musculature maintains the viscera in position and establishes a more favorable position of the diaphragm for its descent with contraction than would be the case with visceroptosis

Can be used as a primary breathing muscle by virtue of active expiratory breathing with passive chest recoil promoting inspiration

COMBINATIONS

Patients with combinations of residual muscular function in different areas of the thorax (e g right intercostals left diaphragm) seem to achieve more effective ventilation for the same vital capacity than if the muscles are restricted to one area (e g right intercostals right diaphragm)

Abdominal pressurized belts can elevate the flaccid diaphragm as an active expiratory effort in the semi upright position and utilize the gravity descent of the abdominal viscera as a passive inspiratory effort

Due to individual differences in the pattern and extent of respiratory muscles paralysis only general guides can be followed for effective positioning corseting and sitting The vital capacity drops very slightly in the normal individual between the supine and sitting positions although the residual volume and expiratory reserve change in relative size This may be significant when all active expiratory reserve is gone as is most often the case in poliomyelitis Most respiratory patients experience a twenty per cent drop in vital capacity when upright This change in a vital capacity already markedly reduced may result in insufficient ventilation in the sitting position A few patients however may increase their vital capacity when sitting

Muscular endurance seems to be a separate function from the measurement of maximum effort so the vital capacity does not uniformly predict the patient s tolerance to unassisted breathing

Manual resistance on upper chest to force diaphragmatic breathing.

Put diaphragm on a stretch—maximum expiration plus thumb pressure up and under costal angles attempting to gain rebound and give the patient a sensation of where to contract

Resist the descent of the diaphragm by thumb pressure up and under anterior rib cage

Place the patient in Trendelenburg and have him use the diaphragm against the resistance of the abdominal contents Additional hand pressure may be used

Sniffing

Lateral Chest

Consciously hold back on the accessories and attempt lateral expansion

Manual pressure to lateral chest utilizing stretch and kinesthetic sense

Manual resistance to lateral chest

For unilateral deficiencies

a) Resist the better side and force breathing in the opposite
b) Resist both sides holding back on the better side
c) Manual pressure to the weak side

Patients with the use of hands and some ability to take resistance to inspiration

a) Resist self with strap around chest
b) Push up against lateral chest and give self resistance

Upper Chest

Consciously eliminate accessories and attempt to gain chest rise

Manual pressure over sternum or pectoral areas for resistance and/or kinesthetic sense

Manually resist and hold back on the abdomen and attempt to force upper chest breathing

General

Inspiratory efforts added to the aid of the respirator

Strengthen accessory muscles of breathing by muscle re-education other than breathing exercises

Patient pushes down with the head on the bed frequently and as soon as possible to maintain and increase strength of the posterior neck and back extensors used in stabilizing the head for accessory neck breathing

Manually resist chin or forehead and have the patient breathe in

EXPIRATION

Strengthen abdominals lattissimus dorsi by re-education other than expiratory exercises

BREATHING EXERCISES

The following is a list of breathing exercises that may be useful for the polio respiratory patient It will be noted that three types of strengthening exercises are presented

Conventional muscle re education

Resistance to the stronger area in an attempt to force breathing in the weaker

Pressure or resistance to the weaker muscles

The latter type has been found to be the most effective but each type may be useful in individual patients

CHEST MOBILITY

USING TANK RESPIRATOR

Increased negative pressure for maximum inspiration (Deep breath technique)

Increased intra tank positive pressure for forced maximum expiration

Abdominal binder to increase thoracic expansion

MANUAL STRETCHING OF THE THORAX, TRUNK AND SHOULDERS

Neck—all motions in the tank as soon as possible (flexion rotation lateral flexion extension)

Rotation of trunk in tank respirator using the hips as a lever

Lift the chest up and move the chest laterally in the tank respirator

Lateral flexion of the trunk—by the hips in the tank and by the shoulders on the bed

Trunk flexion—can be started in the tank by raising the hips and later on the bed by raising the shoulders

Rotation of trunk on the bed by hips and shoulders

Increased shoulder range of motion—particularly flexion and abduction

POSITIONING

Inter scapular pillow

Slight flexion of the neck and back

Abduction of shoulders with pillows triangles etc

MUSCLE RE EDUCATION

INSPIRATION

Diaphragm

Concentrate on rise or ballooning of the abdomen on inspiration eliminating accessory breathing

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Put diaphragm on a stretch—maximum expiration plus thumb pressure up and under costal angles attempting to gain rebound and give the patient a sensation of where to contract
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EXPIRATION

Strengthen abdominals lattissimus dorsi by re-education other than expiratory exercises

Emphasize forced expiration
- Hissing humming whistling singing
- Cough at the end of a maximum expiration
- Blow against resistance—soap bubbles sailboat whistles ping pong ball blow bottle, balloon
- Manual assistance over lower ribs and abdomen to gain more expiration Patient can be taught to do this if upper extremities are strong enough

PHYSICAL AND OCCUPATIONAL THERAPY PROGRESSION IN RESPIRATORY POLIOMYELITIS

PHYSICAL ACTIVITY CATEGORIES

0 NO TREATMENT

No physical or occupational therapy procedures except positioning to maintain good body alignment and comfort

I MUSCLE EVALUATION AND JOINT MOTION: To evaluate neuromuscular status relieve muscle pain, and maintain joint motion

Initiated 48 hours after febrile stage

All motions (with the exception of shoulders) can be carried out in tank respirator (Page 90)

Usually between the 5th and 15th day from onset the patient can tolerate the cuirass respirator for periods sufficiently long enough to carry out all procedures adequately

II STRETCHING, MUSCLE REEDUCATION AND OCCUPATIONAL THERAPY IN BED To increase range of motion and re-establish coordinated neuromuscular patterns of motion

All procedures may be done in the cuirass respirator from the back lying position

For posterior muscle groups the therapist must support the weight of the part and use gravity assisting exercises

III HYDROTHERAPY OR STANDING BED Hydrotherapy utilized to relieve muscle pain and tightness and for muscle reeducation Standing bed to achieve weight bearing and promote circulatory adjustment to the upright position

Transportation of patient may require portable motor for cuirass respirator

Hydrotherapy and standing bed accomplished using cuirass as ordered

Hydrotherapy and standing bed may be done on alternate days if both are indicated

Utilize abdominal support and leg binding to minimize venous pooling

Exercise procedures done at another period during the day

The standing bed is utilized as a convenient and practical method of gaining the necessary circulatory adjustment to the vertical position and at the same time to start weight bearing Patients are started at 30° and over a period of days and weeks the angle and the time are increased Frequent pulse rate and blood pressure determinations are taken before during and following the procedure and the patient is observed for color presence of perspiration, and general feeling of well being as aids in judging the rate of progression

PHYSICAL AND OCCUPATIONAL THERAPY PROGRESSION IN RESPIRATORY POLIOMYELITIS

PHYSICAL ACTIVITY CATEGORIES

IV RECLINING CHAIR, HYDROTHERAPY, STANDING BED OCCUPATIONAL THERAPY IN SHOP To prepare for function and coordination of breathing and balance with activity
   Patients are started in a reclining chair (lounge type with undercarriage) and gradually increased in time and angle towards vertical
   Beginning muscle reeducation in overhead arm slings—activities of a light nature
   Procedures are spread over the day either using the cuirass or breathing alone depending upon medical order

V SITTING STRAIGHT To gain function in the upright position probably using slings and adaptive equipment
   Utilize full reclining back wheel chair for short periods
   Change to conventional straight back wheel chair if possible and practical for the patient
   If it is decided that patient may now sit without breathing aid he should be dropped back to category IV and progressed to his tolerance

VI NO CARDIO RESPIRATORY PROBLEM
   Patient is managed as uncomplicated poliomyelitis

The respiratory patient needs and can receive all the procedures that are ordinarily given in uncomplicated poliomyelitis but can accept them only if given over an extended convalescent period These categories are utilized as a general guide to increasing energy demands on the patient They are arrived at by evaluation and joint staff conference with the physiatrist and orthopedist prescribing the specific procedures which are allowed by the tolerance categories Infections always require retrenchment the patient is put back to activity categories of 0 or I followed by gradual resumption of activity

FUNCTIONAL ACTIVITIES FOR THE SEVERELY INVOLVED RESPIRATOR PATIENT

OBJECTIVES

Function in the upright position
Promotion of outgoing interest and self confidence
Development of occupational and social usefulness

METHODS Integrate energy consuming activities gradually according to the patient s tolerance and ability
Gain at least sufficient range of motion for sitting and dressing
Increase sitting angle and sitting tolerance
Increase neck and trunk balance
Coordinate breathing and talking in the upright position
Utilize activities requiring small energy expenditure—reading, needlework etc

PRIMARY FUNCTIONAL GOALS Self help and self care are stressed with manual activities used to develop the required motions Such goals are relatively low in energy expenditure and of high functional importance
Reading (turning pages)
Communication (write type talk on phone)
Self feeding

SECONDARY FUNCTIONAL GOALS Increase scope of activities in ratio to physical and mental ability
Personal care (make up shave brush teeth comb hair)
Sedentary occupation (household duties office work)
Dressing propelling wheel chair
Transferring (to bed wheel chair toilet shower car etc)
Walking climbing stairs etc

In respirator patients only limited activity can be achieved due to the markedly reduced physiological and muscular capacities for work. Goals of attainment should be set which will accomplish the most useful function with the least expenditure of energy Full exploration of the possible scope of activity is necessary as well as periodic evaluation and the use of self help devices if a much greater and more desirable end result is attained Accomplishments are greater than would be suspected possible from the

extent of paralysis Children are able to complete their education, mothers can supervise and help in the household and often supplement the income Many patients have become partially or totally financially independent through occupations such as merchandising selling services teaching in all of its aspects abstracting, translating providing answering services managing businesses and acting as technical consultants

NURSING CARE—POST ACUTE RESPIRATORY POLIOMYELITIS ROUTINE ORDERS (S W P R C)

When reinstituting oral feedings in the patient recovering from impairment of swallowing a nurse should always be in at tendance

Breathing schedules are posted on the bulletin board in the pa tient s room and in the Kardex Schedules are ordered by the doctor Patients are to be kept on schedules as much as pos sible and no changes are made unless approved by the doctor

EXAMPLE OF BREATHING SCHEDULE

	C F	2/13/56
9 to 12		Alone
12 to 5		Cuirass
5 to 9		Alone
5 P M to 9 A M		Cuirass

There are activity schedules and therapeutic appliance schedules on bulletin boards in patients rooms

RESPIRATORY STUDY CHARTS See example on page 160 These charts are run for 48 hours They are ordered by the doc tor who fills out the schedule The charts are started at 6 A M and completed at 6 A M 48 hours later The patient s pulse respirations and blood pressure are taken BEFORE he is changed to another type of breathing aid and before he starts breathing alone The respiratory rate of mechanical breathing equipment should be counted and recorded in "Respirations" column

If a patient spends all day in the same type of breathing aid or if he is completely weaned the vital signs should be taken every 4 hours 6 A M to 10 P M for 48 hours If the patient spends more than 4 hours in one type of respiratory aid the vital signs should be taken at the end of 4 hours

Example

8 to 2	Cuirass
2 to 5	Rocking Bed
5 to 9	Cuirass
9 P M to 8 A M	Tank

The blood pressure pulse and respirations should be taken at 7 55 A M before taking patient out of tank at 12 noon because he has been in the same type of aid for 4 hours at 1 55 before taking patient off rocking bed at 8 55 before taking patient out of Cuirass

Medications containing iron are to be given between meals and are never given with milk.

Enemas are given PRN An oil retention enema may be given if necessary (See page 76)

Respiratory patients MUST be able to breathe 15 to 30 minutes alone before they are taken to the bathtub Check with nurse in charge before taking such a patient for the first time

Patients may leave the hospital with doctor s permission for specified times

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RESPIRATORY STUDY SHEET 4

NAME W.A. - W. M. 29 Yrs DATE 1/14/56
Wt 136, Ht 74"

Orders 9 - 11 30 Cuirass 4 - 6 Rocking Bed
11 30 - 1 30 Rocking Bed 6 - 8 30 Cuirass
1 30 - 4 Cuirass 8 30 p m - 9 a m Tank Resp
R.R.J.M.D

Date	Time	Kind of breathing (RB, M, T, Alone)	Pulse	Respiration rate	Blood pressure
1-14-56	6 A M	TANK	80	T (20)	140/?
	8				
	9	TANK → CUIRASS	100	T (20)	155/?
	10				
	11 30	CUIRASS → ROCKING BED	78	C (20)	175/125
	12				
	1 30 P M	ROCKING BED → CUIRASS	102	RB (18)	175/130
	2				
	3				
	4	CUIRASS → ROCKING BED	84	C (20)	150/110
	5				
	6	ROCKING BED → CUIRASS	90	RB (18)	140/105
	7				
	8 30	CUIRASS → TANK	84	T (20)	130/110
	9				
	10	TANK	86	T (20)	140/?
	11 & 12				
	1 & 2				
	3 & 4				
	5 & 6				

PATIENT BREATHING ALONE FOR BRIEF PERIOD

Record blood pressure pulse respiration five minutes before changing from one kind of breathing to another If patient is continuously in one kind of breathing and take values again two hours and four hours after starting Don t stop tank or rocking bed when taking values

EARLY EVIDENCE OF INJUDICIOUS RESPIRATORY PROGRAMING OR EXCESSIVE PHYSICAL ACTIVITY

EMOTIONAL LABILITY Disinterest to the immediate environment and personnel addiction to respiratory aids lack of motivation or unreasonable drive develops These findings are frequently observed in the adult patient in the immediate post acute phase and do not signify improper management

SPONTANEOUS BREATHING IS PROGRESSIVELY DYSPNEIC AND RAPID

ALTERATION OF VITAL SIGNS

- Pulmonary compartments
  - Vital capacity arrest of progressive increase (utilize average of several measurements) or decrease
  - Maximum breathing capacity relatively lower than vital capacity
- Circulatory measurements
  - Increase in average pulse rate
  - Instability of 48 hour series of pulse rate
  - Slight increase in average diastolic pressure of 48 hour series
  - Serial and progressive electrocardiographic evidence of shortened P R time and prolonged Q T time

BLOOD CHEMISTRIES Progressive elevation of serum Calcium and fall of serum Potassium Sodium may be high normal to elevated

BLOOD ELEMENTS Increasing or decreasing hemoglobin.

URINE Decreasing specific gravity increasing volume

Determination of stress which ultimately produces serious physiological decompensation is an important aspect of the convalescent care of severe paralytic poliomyelitis The ease with which limited body reserve is exceeded appears to depend upon complex factors such as (a) residual circulatory and respiratory insufficiency (b) the metabolic and nutritional status of the patient, (c) the speed and manner of resumption of physical activity (d) severity of muscle paralysis and (e) individual constitutional characteristics

Separate identification of the contributing factors is not often possible or so important as the elimination of injudicious respiratory scheduling and excessive activity The detection of excessive activity may be simplified by the comparison of repeated surveys of the type indicated before

SIGNS AND SYMPTOMS OF SEVERE STRESS

Irritability, drowsiness fatigue lack of cooperation.
Increased need and desire for breathing assistance dyspnea "all or none" effort
Increase in body weight, edema puffy facies
Hirsutism, seborrhea, acne
Nutritional disturbances gastrointestinal disturbances with abdominal distention vomiting bleeding
Dehydration temperature elevation
Decrease in vital capacity from earlier values
Progressive alteration of vital signs
  Marked increase in pulse rate and fluctuation with daily activities
  Systolic and diastolic hypertension
  Electrocardiographic evidence of marked decrease in P R time and prolongation of Q T clockwise shift of QRS vector (right heart preponderance) high peaked P waves change in shape of T waves
Blood chemistries Sodium retention and potassium depletion elevated calcium increased blood urea nitrogen
Urine Elevated 17 ketosteroids failure of renal concentration and polyuria and reversal of the normal Na K excretion ratio

Since severe stress involves many body functions there is no single reliable indicator Early detection depends upon observation of parallel changes in several body functions such as mental condition declining vital capacity circulatory status elevated blood pressure altered serum electrolytes etc Most frequently the trend of a series of relatively simple measurements forestalls improper progression of respiratory and physical activity In addition conservatism in balancing activity versus inactivity may prevent a serious disturbance of a specific body function such as markedly elevated blood pressure which may be irreversible There is increasing evidence that the poliomyelitis patient may achieve more useful activity and a better respiratory prognosis with fewer intercurrent metabolic and circulatory complications if such a philosophy of treatment is utilized. It is a cautious program of evaluation care and rehabilitation which initially takes more time and effort.

The relationship of these clinical signs and symptoms to adrenocortical "stress" responses is not established This however does not alter their importance in relation to the programing of respiratory assistance and physical activities

HOME CARE PLANNING FOR THE RESPIRATORY PATIENT

PRELIMINARY

EARLY AND PROGRESSIVE PLANNING IS ESSENTIAL
- Periodic evaluation and programing by the entire staff
- Discussion of the program and aims with the patient and family

PSYCHOLOGICAL AND SOCIAL ADJUSTMENT
- Gradual adjustment of the patient and family to the practical significance of his medical, social, and psychological prognosis (including the fact that the patient may not make full recovery)
- Exposure to group of similarly impaired patients and especially to those who return from home for checkups
- Evaluation of patient and family
- Encourage participation in outside social activities (with doctors and nurses in attendance)
- Gradual introduction of the family to the complications of care
  - Attendance at above social activities with patient
  - Short home visits with doctors and nurses in attendance and later assuming full responsibility
  - Week end home visits
- Definite plans for home care outlined with the patient and the family several months previous to anticipated discharge

POINTS WHICH DETERMINE PROGRAM
- Pattern of response in serial evaluation of the physiological reserves
- Fatigue response to carefully regulated breathing physical and occupational therapy schedules
- Occurrence and response to intercurrent infections and complications
- Requirements for further rehabilitation
- Resources of family and community (financial, emotional interpersonal relationships vocational etc)
- Availability of medical follow up and remedial hospitalization

The ultimate purpose of treatment is decentralization of the patient from special services to home care This should be kept in mind throughout the patient s stay and the foundations for successful weaning of the patient from the hospital should be started upon admission of the patient.

There must be integration and joint participation in the planning for the home care of severe respiratory patients Each member of the hospital team should be kept informed of the patient s progress within the area of each of the other members of the team Only in this manner is it possible to have consistency and continuity in the attitude presented by each of the staff to the patient and his family Repetitive reassurance and interpretation from each area is required for the complete adjustment of the patient and his family Without this underlying philosophy the structure of the hospital program as well as home care fails

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Treatment should not be considered completed upon the patient's discharge from the hospital Through periodic re evaluation the patient's program can be supervised and continued at home when maximum benefit from specialized and expensive hospitalization has been reached Such a plan also gives the patient and family security and self confidence to take on home care It is often desirable to have "therapeutic" interims at home to neutralize "hospitalitis" to practice learned activities and to gain better emotional adjustment in order to proceed more effectively with intensive rehabilitation at a later date

Home care for the severely involved patient demands adequate medical follow up and the assurance of hospital readmission for intercurrent problems

MEDICAL RESPONSIBILITY DOES NOT CEASE WITH DISCHARGE

DISCHARGE PLANNING

MEDICAL REQUIREMENTS

Evaluation of the family composition and physical setting of the home to determine the needs of the individual

Adaptation of the patient to less expensive and complicated breathing devices

Well defined schedule within the patient s tolerance keeping in mind that the initial phase of home adjustment is fatiguing

Complete summary, status report and outline of medical care to the patient s responsible physician

Orientation and instruction of the family and attendant prior to discharge on diet care equipment and simplified physical and occupational therapy procedures

Insistence on the hazard of intercurrent complications their signs etc

Periodic re evaluation as dictated by the patient s individual requirements

COMMUNITY PARTICIPATION

Provision of special respiratory and mechanical devices (breathing aids wheel chair lifter emergency generator) and attendant as deemed necessary in cooperation with the financially responsible groups

Provision for maintenance and repair of equipment

Provision for emergency hospitalization and supplementary respirator aids

Evaluation and solicitation of recreational educational and vocational facilities

Arrangements for transportation to home including vehicle power moving of equipment and patient care

ADJUSTMENT OF PHYSICAL SETTING

Room location and size door widths emergency exit

Wiring and power

Bathroom facilities

Bed–type and height

Storage space for equipment

Provision for going outside the home–ramp portable breathing aid

APPENDIX

EQUIPMENT NECESSARY FOR TRACHEOTOMY TRAY

I Jackson full curved standard tracheotomy tubes with tape sizes
0 1 2 3 4 5 6 7

II Two 5 cc syringes with 2 each of the following needles
25 g x 2⅝′
22 g x 1½
21 g x 1½
20 g x 1½

III 1 basin for saline
2 rubber catheters No 10 and No 12 F
2 medicine glasses
1 medicine dropper
assorted suture needles and suture
plain catgut 000 and 00
black silk 2 and 0
cotton suture No 30
2 small draw sheets
4 towels
2 packages of flats without cotton or use folded gauze
8 applicators

IV 1 Trousseau dilator
2 Bard Parker knife handles No 3
1 No 10 blade
1 No 15 blade
2 pairs suture scissors
1 Mayo curved dissecting scissors
2 Tissue forceps 1 plain 1 with teeth
1 grooved director 1 probe
2 tracheal retractors
1 Anthony suction tip
4 Mosquito forceps (straight)
4 Mosquito forceps (curved)
2 Allis forceps
2 large forceps (curved)
2 large forceps (straight)
1 Ochsner forceps (straight)
2 sponge forceps
1 needle holder
4 towel clips
1 trachea hook

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4 towel clips
1 trachea hook

1 Good lite transformer
Source Good lite Co 7638 Madison St. Park Forest, Ill
1 Good lite reflector—adjustable headband
1 plastic face shield— " " (Broyles)
1 nasal speculum (Ingalls)
Source Geo Pilling & Son Philadelphia #3865
1 pr protective glasses—clear non-corrective lens
(May be purchased from any local supplier)

IV Suction machine (Gomco)
Source The Surgical Manufacturing Corp Buffalo N Y

V Oxygen supply should be on hand and ready for immediate use

VI *Mucous trap (if specimen is desired)*

VII Tracheotomy tubes Source—Geo Pilling & Son
Jackson trachea tube—full curve sterling silver
with pilots Sizes 0 through 7 BR 4000-BR 4040
Jackson trachea tubes—short luer type
Sizes 0 through 7 BR 4200-BR 4245

EQUIPMENT NECESSARY FOR BRONCHOSCOPY TABLE

I Bronchoscopes Source—Geo Pilling & Son Philadelphia Pa

			Cat No
#40 7	9 mm x 40 cm	Two light carrier	BR 1045
#40 6	6 mm x 40 cm	" "	BR 1025
#30-4,	5 mm x 30 cm	" "	BR 1005
#30-3½	4 mm x 30 cm	" " "	BR 1000
#20-4	3 mm x 30 cm	"	BR 920
#20-3	3 mm x 30 cm	" "	BR 900

Metal aspirating tubes for above scopes BR 3200 BR 3340
Cleaning brushes for above small medium large BR 2830
2 battery boxes (for batteries #2 LP) E 5700

II Laryngoscopes

Miller #1	One light	BR 1845
Guedel		BR 4847
Wisconsin		
#12 14 16 Jackson	Twinlight	105 115 120

3 curved laryngoscopes for use in tank
MacIntosh #3 BR 4845
Miller #4 BR 4847
1 special offset Forreger blade for use with tank
2 Forreger battery handles for folding scopes

III Miscellaneous

5 laryngeal mirrors Sizes 0 2 3 4 and 5 M S
3 bite blocks large medium small BR 3000 BR 3025
3 metal mouth gags 1 rubber protected #39
1 rubber protected #70 E 5945
1 all metal (Haslam) E 5940
Laryngo forceps with cutting jaws E 7045
1 long curve metal forceps (any make)
1 DeVilbiss atomizer with 4% cocaine solution
Assorted plastic airways (intubation tubes)
Sizes 0 through 10 Magill tube (Portex)
Source Hawkes Division of Sierra Engineering Co
123 East Montecito Sierra Madre Calif
4 Berman plastic oral airways
Sizes—infant child medium large #26719-#26722
Source American Hospital Supply Company

The definitions of symbols used in this representation of the lung compartment and used commonly in pulmonary physiology include *[26]

- TLC = **Total Lung Capacity** = the total gaseous volume of the chest compartment at the point of maximal inspiration (Average 6 000 ml)
- VC = **Vital Capacity** = the maximum possible voluntary breath beginning at the position of maximum inspiration or expiration (Normal minimal values See page 175) (Average 4 800 ml)
- TV = **Tidal Volume** = the volume of a single breath (Average 350-800 ml per breath for adults)
- R = **Respiratory rate** = the number of breaths per minute (Normally 10 16 breaths per minute)
- MV = **Minute Volume** = volume of air breathed per minute = tidal volume x rate (Normally 5-8 liters per minute)
- MBC = **Maximum Breathing Capacity** = maximum amount of air which can be breathed voluntarily by increasing rate and depth of breathing per unit time (Usually measured for 15 seconds to minimize hyperventilation and converted to liters per minute) Normally the physiology laboratory determines its own values (range from 74 95 liters/minute for females and 90 125 liters/minute for males)
- RV = **Residual Volume** = the volume of air remaining in the lungs after a forced maximal expiration (Average 1 200 ml)
- FRC = **Functional Residual Capacity** = the residual volume of the lungs plus the expiratory reserve volume (Average 2 400 ml)
- ERV = **Expiratory Reserve Volume** = the volume of maximum expiration starting at the resting lung position (Average 1 200 ml)
- IC = **Inspiratory Capacity** = the volume of maximum inspiration starting at the resting lung position (resting expiratory level) (Average 3 600 ml)
- IRV = **Inspiratory Reserve Volume** = inspiratory capacity minus the tidal volume (Average 3 100 ml)

Resting lung position or resting expiratory level = the lung position with respiratory muscles relaxed and the airway open

Dead air space = the volume of air in one breath that occupies the portions of the airway not participating in gas exchange (Normally 110 ml for women and 150 ml for men)

Effective alveolar ventilation = the portion of the minute volume of ventilation which reaches those areas of the lung concerned

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* Values given are only average for the *adult male* These figures change with position of the body age body size sex and altitud above sea level They may also be considerably different in a homogeneous group so that variations must be larg to be abnormal

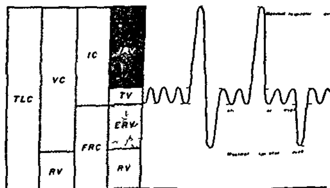
PHYSIOLOGY OF RESPIRATION APPLIED TO POLIOMYELITIS

"Normal" respiration in the quiet steady state may be defined as the optimal adjustment of the rate and depth of breathing which meets the metabolic demand for oxygen uptake and carbon dioxide elimination with minimal work by the respiratory muscles The ebb and flow of air into and out of the lungs is brought about by rhythmic changes in the volume of the chest

The sequence of events in pulmonary ventilation include

- Rhythmic activation of the inspiratory musculature
- Muscular contraction leading to enlargement of the chest compartment
- Establishment of a mouth to alveolus (trans airway) pressure difference which is higher at the exterior than in the lungs
- Air inflow into the lungs which equalizes the pressure differences (Inspiration)
- Neurogenic inhibition of inspiratory muscles as a result of lung inflation
- Decreasing volume of the chest compartment due to elastic recoil of the distended lungs
- Reversal of airway pressure differences
- Lung air outflow to equalize the pressure difference (Expiration)

The compartments which the air in the lungs occupies under static conditions (absence of movement) is illustrated by this figure

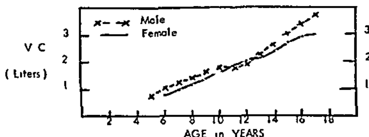


From *The Lung* by Julius H Comroe Jr *et al* Figure 2, Page 6 Published 1955 by The Year Book Publishers Inc., Chicago Ill Reprinted with the permission of author and publisher

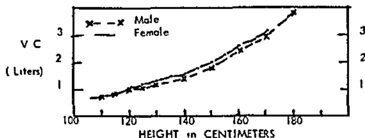
MINIMAL OBSERVED VITAL CAPACITY VALUES IN ADULTS AND CHILDREN

(Values given are 2 standard deviations below the mean)

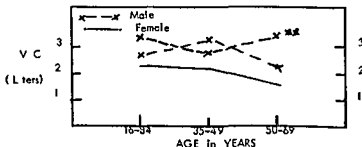
CHILDREN AND ADOLESCENTS VS AGE [27]



CHILDREN AND ADOLESCENTS VS HEIGHT [28]



ADULTS VS AGE [29 30]



These values are given as statistically significant minimum vital capacity measurements below which significant reduction in vital capacity must be considered to have occurred

with gas exchange (Tidal volume minus Dead Space x Rate) Averages about 3 5 to 5 0 liters per minute

It should be pointed out that the same minute volume of breathing obtained by rapid rates and shallow tidal volumes achieves less alveolar ventilation than when it is obtained by slower rates and larger tidal volumes *This is true* because with rapid shallow breathing the dead space of the lungs must be emptied and filled more times so that less air is available for the emptying and filling of the portions of the lung concerned with gas exchange

The terms encountered most frequently by the clinician in the management of respiratory poliomyelitis include vital capacity, tidal volume, rate of breathing minute volume and maximum breathing capacity It is necessary to measure these values for the proper evaluation of pulmonary ventilation All of these measurements can be easily made with a recording spirometer, ventilation meter or some BMR machines and a watch * (With the exception of maximum breathing capacity)

The clinician must also pay careful attention to the pattern of the breathing effort *Serious disturbances in respiratory regulation can occur in brain stem involvement in poliomyelitis* The pattern of ventilatory effort can be suitably displayed with a recording spirometer

The effectiveness of pulmonary ventilation is measured by the accomplishment of sufficient oxygen uptake for metabolic needs and the elimination of carbon dioxide in proportion to production This usually preserves arterial oxygen content and hemoglobin saturation and maintains the arterial carbon dioxide content and partial pressure within a range which permits optimal pH of the blood Exceptions are encountered only at extremes of metabolism or during voluntary ventilatory disturbances in the healthy person The procedures for the determination of gas and blood chemical values are not generally available with the exception of the oxygen uptake This can be measured easily with an ordinary basal metabolism spirometer

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For sources of suitable spirometers and ventilation meters see page .0

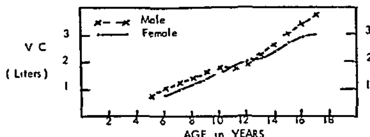
For general information in regard to spirometers see pages 78-82, and 94 102, *Modern Methods in Medical Research* Vol II Edited by J H Comroe Jr The Year Book Publishers Inc. Chicago Illinois 1950 Pages 181 188 and 206 214 of this same volume give information concerning specific test of lung function

The reader is referred also to *The Lung* by J H. Comroe Jr *et al.*, The Year Book Publishers Inc., Chicago Illinois 1955 as a general reference on pulmonary physiology

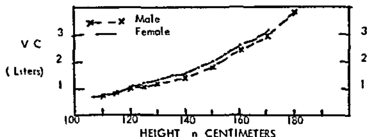
MINIMAL OBSERVED VITAL CAPACITY VALUES IN ADULTS AND CHILDREN

(Values given are 2 standard deviations below the mean)

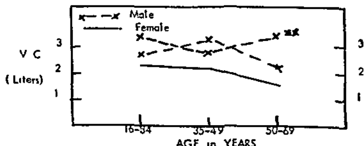
CHILDREN AND ADOLESCENTS VS AGE [27]



CHILDREN AND ADOLESCENTS VS HEIGHT [28]



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For sources of suitable spirometers and ventilation meters see page 20

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Practically the use of such data is limited to the adjustment of ventilation during artificial respiration The estimation of the adequacy of ventilation in the poliomyelitis patient who is breathing spontaneously is most reliably indicated by the vital capacity Tidal volumes and minute volumes are difficult to obtain with accuracy in the febrile acutely ill patient However as soon as artificial respiration is utilized measurement of the tidal volume is usually possible and will aid adjustment of artificial respiration to prevent underventilation

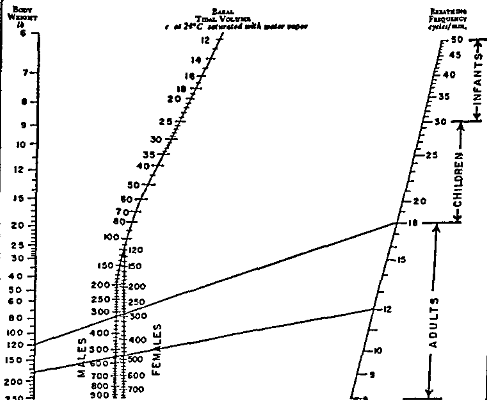
The practice of spirometry in the patient is simplified if one considers that it is applicable to older children and adults and great care is exercised in explaining and demonstrating the procedure to the patient Several measurements may be necessary to insure reliable determination in the vital capacity A mouthpiece is better than a mask. The nostrils should be occluded with the tips of the fingers rather than by vigorously squeezing the nose Recording spirometers are most valuable for permanent records which can be viewed serially

MECHANICS OF BREATHING The pressures which are generated in the thorax during the breathing effort reflect the muscular work which is being expended in enlarging the chest compartment and overcoming the forces which tend to impede inflation of the lungs Fortunately the lungs and chest are so arranged that the muscular movement which accomplishes pulmonary ventilation begins at a balanced resting position or volume at which the tendency of the lungs to collapse and the chest to enlarge is equalized The work involved in enlarging the diameters of the chest compartment in quiet breathing must then overcome first, the reluctance of the partially inflated lungs to be further distended (by virtue of their elasticity) secondly, the frictional resistance to air movement in the air passages and lastly the friction generated from moving the thoracic tissues and the abdominal contents A considerable portion of the work of breathing is utilized in stretching the lungs or overcoming their elasticity and in neutralizing frictional resistance to the air flowing into them On the one hand slow deep breathing requires more work for overcoming elastic properties On the other hand rapid shallow breathing requires greater speed of air movement and thereby increases air flow resistance In the quiet steady state a breathing rate is chosen at which minimum energy expenditure occurs Normally this utilizes only a small fraction (less than five per cent) of the oxygen consumed by the body As pulmonary ventilation increases to meet larger metabolic demands work increases and efficiency decreases In an analogous manner as the disease state produces changes in the airway in the lung tissue and in the tissues and position of the chest less efficient pulmonary ventilation may develop for a given amount of respiratory muscular effort

Some knowledge of the mechanical properties of the lungs and chest is

NOMOGRAM FOR PREDICTION OF MINIMAL TIDAL VOLUMES

Nomogram for predicting the Tidal Volume necessary for normal ventilation at different rates of breathing according to body weight *



Correction of these values can be made in the following manner

Add 10% for daily activity and eating

Add 5% for each degree of fever °F above rectal normal 99°

Add 5% for each 2 000 feet of residence above sea level

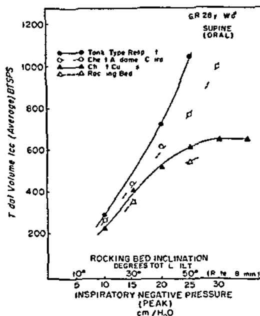
The values given above represent minimum values in most clinical situations below which underventilation can be considered to have occurred

A spirometer or ventilation meter is necessary for the application of this nomogram

* Reproduced from "Clinical Use of a Nomogram to Estimate Proper Ventilation During Artificial Respiration," by Edward P Radford, Jr., *et al.*, *The New England Journal of Medicine 251* 22, Figure 1 (Nov 25) 1954 with the permission of the author and publisher

For practical purposes the most useful index of proper function of artificial respiratory devices is the adjustment of applied pressure and rate to provide ventilation in the suggested ranges indicated on page 29 and to insure that the results do not drop below the values obtainable from the

RELATIVE VENTILATORY EFFECTIVENESS OF SEVERAL RESPIRATORY DEVICES



This figure illustrates the tidal volume obtained at equivalent respirator pressure settings in the same subject. The rocking bed values are placed in the figure empirically since the angle of inclination rather than pressure describes the function of the device

nomogram for tidal ventilation on page 176 in this section Furthermore careful and continuous clinical observation of the patient s responses should be carried out

Once satisfactory pulmonary ventilation has been achieved in the tank respirator patient, it is necessary to appreciate the differences in ventilatory efficiency of the various auxiliary breathing devices which are frequently employed in early convalescence

The illustration indicates the remarkable and consistent differences in

therefore valuable in the management of the poliomyelitis patient. The effect of muscular paralysis is both clear and unmodifiable. The elastic behavior of the lungs and to a lesser extent of the chest may be altered in poliomyelitis patients so that they are less compliant.[31, 35] This increased resistance to elastic stretch or decreased "compliance" may diminish the ventilatory effectiveness of artificial respiratory devices.[3, 33] Furthermore the respiratory patient may readily develop obstruction or narrowing of the air passages as a result of mucus accumulations in the trachea and bronchi, breathing through a small tracheal tube, and constriction of the bronchioles so that airflow resistance increases. (See page 46.) Pulmonary and circulatory complications may affect both elasticity and the frictional characteristics of the lung tissue. Accordingly, changes in elasticity of the lungs and situations which lead to increased resistance to air inflow and outflow should be appreciated in order to adjust for their effect upon pulmonary ventilation.

The clinician can readily detect these unfavorable changes in the lungs since they diminish the inflation of the lungs at a given respirator pressure. Recording the tidal volume of the patient in the tank respirator at the same pressure and at regular intervals during the course of illness often demonstrates a sudden or progressive reduction in tidal exchange with the development of pulmonary complications. These decreases in tidal volume (measured at the same rate of respiration) are most often the result of airway obstruction. When ventilatory problems are suspected to result from such increased airflow resistance, slower rates of breathing and deeper tidal excursions may help to minimize this after all suitable corrective procedures have been carried out. In addition, the decreased compliance of the poliomyelitis patient may account for the reduced ventilatory effectiveness of comparable respirator pressures when contrasted to that obtained in normal subjects.

ARTIFICIAL RESPIRATION The use of artificial respiratory devices to ventilate the lungs depends upon the application of pressure to create a pressure difference between the alveoli and the exterior of the body promoting air inflow. In most instances air outflow depends upon the passive elastic recoil of the lungs. The effectiveness of respirator pressures also depends upon the mechanical characteristics of the airway, the elastic properties of the lungs and thorax, and upon air flow frictional resistance much as in normal breathing. Much larger applied pressures are necessary, however, to provide adequate ventilation than are generated in the chest compartment during comparable tidal exchanges in normal breathing. The shift from voluntary spontaneous breathing to artificial respiration is a large one and considerable differences exist between them, particularly from the standpoint of the normal variations in rate and depth of breathing.

PRINCIPLES OF THE OPERATION OF THE TANK RESPIRATOR

AVOID VENTILATORY EMERGENCIES DUE TO IMPROPER USE OF EQUIPMENT BY UNDERSTANDING THE PRINCIPLE OF OPERATION

Principle of Operation

- The patient s body is enclosed in the respirator with his mouth open to the atmosphere
- The bellows of the respirator creates a sub atmospheric air pressure within the tank and therefore within the patient s chest compartment
- Air from the relatively higher pressure of the atmosphere is forced into the lungs since air pressures tend to become equal
- Air flows out due to the passive recoil of the distended lungs as the tank pressure returns toward atmospheric pressure
- The volume of each breath depends upon
  - The amount of negative pressure in the tank (more accu rately the pressure difference between the chest compart ment and the exterior at the mouth or tracheal opening)
  - The mechanical properties of the patient s airway lungs chest wall and abdominal cavity
- The minute volume of breathing depends on the pressure in the respirator and the rate of cycling per minute

The tank respirator is a pressure breathing device It periodically subjects the patient s thorax abdomen and extremities to a negative or sub atmospheric" pressure by virtue of its bellows like action A pressure gradi ent or difference is thus set up between the chest compartment enclosed in the body of the tank and the upper airway at the mouth open to the atmosphere As the pressure in the respirator and thus in the chest com partment declines below that of the atmosphere the pressure at the oral cavity and trachea becomes positive in relation to the chest compartment Air inflow results from the tendency of air movement to equalize differences in air pressure The inflated lungs then passively recoil as the pressure returns toward atmospheric in the interior of the tank and air outflow is achieved

depth of tidal ventilation achieved by the tank respirator the most effective device the chest abdomen cuirass respirator the chest cuirass respirator and the rocking bed in the same subject[34]

The most practical implication is that the effectiveness of the auxiliary devices is considerably less than the tank respirator so this must be taken into account in pressure adjustment Ventilatory measurements should be made for their proper employment.

VENTILATION DISTRIBUTION AND BLOOD PERFUSION RELATIONSHIPS of the lungs occupies an important investigatory area in pulmonary physiology This refers to the complex problem of describing quantitatively the manner in which the arterial blood in the lungs is exposed to and reaches equilibrium with the alveolar gases

Furthermore disturbances of ventilation distribution and blood perfusion in the lungs probably occur in the course of severe poliomyelitis (See page 48) The patient with involvement of the brain stem and pulmonary and circulatory complications may present alterations in arterial chemistry which can be explained *only upon such a basis For the clinician* treatment *of the provocative conditions is more important* and practical than the demonstration of these physiological abnormalities

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Inability to produce sufficient pulmonary ventilation with the tank respirator is more often a consequence of altered expansibility of the lungs than a result of insufficient negative pressure Increased resistance to air inflow from an obstructed airway is the most common problem Additionally changes occur in the elastic properties of the lungs and chest wall which impede distention of the lungs [85] The development of complications leading to increased resistance to air flow in the air passages and changes in the elastic properties of the lungs usually impede pulmonary inflation This results in a decreased tidal exchange at the same respirator negative pressure setting

GLOSSOPHARYNGEAL BREATHING

USE OF THE PHARYNGEAL MUSCULATURE TO PUMP AIR INTO THE LUNGS

USE Glossopharyngeal breathing may aid the respiratory patient by permitting him to
- Talk and speak loudly
- Take a full inspiration for coughing efforts
- Increase chest expansion
- Eliminate complete dependence upon mechanical aids and to facilitate care and changes in equipment in the apneic patient.

Use of glossopharyngeal breathing demands careful assessment of its physiological effects on circulation The stroke volume of each swallowing maneuver should be measured so a proper "tidal" volume and safe period of expiration can be determined Most patients who have learned glossopharyngeal breathing spontaneously tend to pump air in for long intervals with infrequent expiratory efforts This in effect is a Valsalva maneuver which progressively interferes with venous return and thus cardiac output Pacing of glossopharyngeal breathing should therefore include a careful decision as to the safe number of cumulative "breaths" per minute and number of swallowing strokes per breath This may be done by simple spirometric measurements Periodic circulatory evaluation is indicated as described in Methods of Evaluating the Respiratory Patient for the Progressive Weaning and Rehabilitation Program (See page 144) Glossopharyngeal breathing should not be pushed to the point of physiological compromise just as this is avoided in careful scheduling of spontaneous breathing cuirass time etc

"Step 1 The cycle begins with the taking of a mouth and throat full of air by depressing the tongue and the floor of the mouth There is a widening of the pharyngeal space While this is done the laryngeal orifice is kept closed

Step 2 The lips are closed and the soft palate raised to trap the air

Step 3 The larynx is opened and the floor of the mouth is raised while the pharynx is constricted This together with progressive backward motion of the tongue forces air through the opened larynx into the trachea

Step 4 The larynx is closed and air is trapped in the trachea and lungs

These four steps are repeated as in a pump Each stroke of the piston following the preceding one As in a pump there are check valves at the entrance to the mouth and at the larynx to close off the air at the proper time From a series of ten such strokes the amount of air accumulated in the lungs is comparable to a good sized breath Since the glossopharyngeal pump is reciprocal in motion the timing of the air movement through the larynx alternates with the movement through the entrance to the mouth

The stroke by stroke filling is inspiration Expiration results when the larynx is opened permitting all the accumulated air to escape passively[24, 27]

THE MANUAL ASSISTED COUGH

TECHNIQUE

The assistant stands at the head of the patient s bed (usually on a chair) so that his waist is above the patient s head.

Place the hands on the patient s chest with the heels of the hands just below the clavicle and with the fingers directed distally

The patient takes a maximum inspiration and closes his glottis The assistant quickly and forcefully sustains a downward and forward pressure on the chest with his body weight behind the push of the hands As maximum pressure is reached the patient produces the cough by opening his glottis

An abdominal binder increases the effectiveness of the cough. (A folded sheet under the back, pulled tightly across the abdomen and secured under the hips by the patient s weight makes a good binder)

If the patient is using a cuirass respirator it can be left in position and the assistant s hands slipped under the shell Some patients can be coughed with manual pressure on the outside of the shell.

An Ineffective Cough May Be Due to

Insufficient inspiratory volume—adults with 300cc vital capacity or lower need to supplement inspiration with glossopharyngeal breathing positive pressure through the mouth or a maximum inspiration with the cuirass respirator set at its highest effective pressure

Poor coordination between the patient and assistant.

Insufficient pressure or a quick, jerky motion by the assistant.

Inadequate binding of the abdomen

The manual assisted cough is useful for patients who cannot produce an effective cough due to respiratory and abdominal muscle paralysis This method eliminates placing the patient in the tank respirator for coughing only or the necessity of having a cough machine Patients with some spontaneous breathing can gain a better cough manually than with mechanical apparatus The technique is not adaptable if the patient is in a tank respirator and it requires great coordination on the rocking bed.

The *technique requires two to three sessions for mastery* Regular cough-

These four steps are repeated as in a pump Each stroke of the piston following the preceding one As in a pump there are check valves at the entrance to the mouth and at the larynx to close off the air at the proper time From a series of ten such strokes the amount of air accumulated in the lungs is comparable to a good sized breath Since the glossopharyngeal pump is reciprocal in motion the timing of the air movement through the larynx alternates with the movement through the entrance to the mouth

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THE VACUUM CLEANER ASSISTED COUGH FOR RESPIRATOR PATIENTS

USE ORDINARY TANK TYPE VACUUM CLEANER

Place patient in a tank respirator and carefully adjust collar and all portholes for the best possible seal against leaks
Reduce cycling rate to the slowest position (12 per minute)
Increase inspiratory negative pressure to the maximum value (25 to -30 cm of water) to obtain maximum "tank" inspiration
Close expiratory positive pressure valve or flap completely for maximum positive pressure (+5 to +10 cm of water)
The patient is instructed to "hold" his breath after each maximum inspiratory cycle of the respirator This is achieved by voluntary closure of the glottis after a full inspiration
While the patient is holding his breath and the respirator cycle is going toward the positive expiratory side the intra tank pressure is supplemented by attaching the vacuum hose to the respirator It is connected to the "blow" or positive pressure side of the cleaner A porthole may be used with a large towel wrapped around the hose to maintain a seal It is best to make a fitting for the respirator designed to receive the vacuum cleaner hose with a simple shut off valve otherwise for each cycle the hose must be removed and the porthole closed
When the positive pressure in the respirator reaches 25 to 40 cm of water the patient is told to cough "
Repeat no more than 4 times during a treatment

DO NOT USE NEGATIVE PRESSURE GREATER THAN 30 cm of water if patient has atelectasis

The vacuum cleaner serves simply to supplement the respirator positive pressure during expiration and provides a pressure gradient for the patient after a full inspiration which is sufficient to produce a rapid expiratory air blast when it is triggered by the sudden opening of the glottis Usually the patient is able to "clear his throat and expel large quantities of mucoid material The disadvantages of the procedure include it is usually effective only as a preventive measure it is inadequate in the tracheotomized patient with open tracheotomy tube there is need for voluntary synchronization of the patient s effort and there must be effective sealing of the respirator collar

ing in the mornings and at any time needed to clear accumulated secretions is beneficial and gives the patient both confidence and competence should an emergency arise

The upper chest technique is more effective and causes less discomfort than pressure on the lateral chest or abdomen [38] A similar technique to this employs manual pressure to the interscapular area of the back with the patient in the prone position This position limits inspiratory volume

RESPIRATORY EQUIPMENT

Optimum use of equipment such as cuirass respirators and rocking beds depends largely upon the experience and proficiency of the personnel and adequate mechanical maintenance Operation is best demonstrated by bed side instruction and participation The absolute necessity of familiarity with equipment cannot be overemphasized for its successful employment in the care of the convalescent respirator patient Cuirass respirators have been utilized for brief periods for nursing care and physical therapy in the earliest afebrile phases in the uncomplicated patient In general cuirass respirators and rocking beds have not been utilized as a primary breathing aid at the onset of respiratory muscle paralysis because there is little doubt that they have less maximum ventilatory effectiveness than the tank respirator

The following section on the maintenance and specifications of commonly used respiratory equipment is based upon the experience of a Respiratory Center and the Equipment Maintenance Pool of the National Foundation for Infantile Paralysis Inc at Jefferson Davis Hospital.

The section is intended to highlight important general information not readily available It is not complete nor can it be since any single experience will not include all of the different types of equipment available throughout the entire country

This material must not be considered either an endorsement or a criticism of a particular manufacturer s product The majority of the manufacturers continuously modify or alter equipment based upon experiences reported by users Thus descriptions of apparatus cannot keep pace with changes These suggestions however apply to currently available apparatus

This information has been included in the syllabus because proper operation and maintenance of respiratory equipment is obviously of the utmost importance for the successful medical care of the respirator patient

The method does not duplicate the efficiency of a normal cough in which intact abdominal musculature produces an unusually forceful properly timed expiratory air blast which is triggered by sudden glottic opening Failure of the method is indicated by a continuation of the signs and symptoms of retained tracheal secretions

Do NOT use high negative respirator pressures when over distension and possible rupture of ventilated lung tissue may occur as a result of atelectatic lung tissue which is not likely to expand

OPERATION OF RESPIRATORY EQUIPMENT

TANK RESPIRATOR

TO CHECK OPERATION OF TANK RESPIRATOR

Place a piece of cardboard or a pillow in the head opening Turn on the motor and adjust valve to increase negative pressure The gauge should record at least a maximum negative pressure of 28-30 cm of water at a rate of 20 strokes per minute

COMMON FAILURES AND THEIR CORRECTION

INSUFFICIENT NEGATIVE PRESSURE

On tanks check for leaks around portholes collar extra outlets cot adjusting handles In cuirass respirators check hoses and shells

Negative pressure release valve sometimes sticks in the open position

If gauge does not move check connecting hose to gauge if present.

Head end gaskets become defective but more often there is a towel sheet or strap preventing an adequate seal

EXCESSIVE POSITIVE PRESSURE—usually is caused by an inward leak on the negative stroke

Look for leaks allowing too much air to be drawn into the respirator on the negative stroke and which cannot be exhausted on positive stroke Maximum negative pressure will be decreased

Sometimes the positive valves stick closed or connecting rods and handles become loose and do not open the valve Find the valve to which the control connects and turn this valve by hand in an emergency

MOTOR FAILURE—is not usually due to a burned out motor on the tank respirator

Check the following things first

Belt in place

Electric plugs for tightness of connection (Emerson has extra plugs on motor)

Plug a floor lamp into the plug on the side of the tank. If light operates current has traveled to the switch on the tank. If light fails to operate tank connecting electrical cord may be faulty or damaged by moving parts

Then plug electric lamp into the plug on the motor If lamp lights when switch is on the short is between motor plug and motor If lamp fails to light the trouble is in the switch

Motor Failure—have replacement motor available

GENERAL CONSIDERATIONS IN MAINTENANCE OF RESPIRATORY EQUIPMENT

UNDERSTAND THE MACHINE BEFORE MAINTENANCE OR REPAIRS ARE ATTEMPTED!

Always read the manual of instructions and follow the lubrication instructions

Do not over oil the motors

Keep the equipment clear of the walls and furniture to prevent moving parts from being damaged

Avoid the use of other large electrical appliances on the same circuit

Promptly replace worn or defective plugs and cut or bruised cords

Keep a lamp or circuit tester available in order to check quickly the outlet for power

Know in advance the position of an alternate outlet on another circuit

Lock or block the casters before working on equipment

CAUTIONS

Do not attempt to repair or lubricate machines while they are in operation—injuries and damage to equipment will result

Do not leave machine plugged in circuit even though switch is off Some wiring is exposed and electrical shock can occur

PREVENTIVE MAINTENANCE IS CHEAPER AND SAFER THAN EMERGENCY REPAIR!

* Both manufacturers make Junior Size Models which achieve smaller size and include faster rate range Emerson also manufactures an infant size tank respirator A respirator extension for patients who are over 6 feet in height is also available

* Motors for special operating voltages and cycles or direct current use can be provided

* Width of the Emerson can be reduced to 30½ inches by removing the cot clamps and cot clamp bolts height to 55 inches by removing the pressure gauge and length to 93 inches by removing the head rest

**** Recent models of this respirator have used an instantly available emergency hand pump lever

MAINTENANCE SUGGESTIONS

Drinker Collins Tank Respirator

Connecting hose can be replaced with automobile windshield wiper hose on models with the gauge on the side mounted instrument panel

Leakage through arm port doors can be minimized with shims under the door retaining clip when sponge rubber port hole becomes soft and worn

Failure for rate change to occur is usually due to failure of the split pulley on the gear box Apply lubricant to pulley so that it works freely and separates easily

Emerson Tank Respirator

Full range of rate may not be obtained with worn motor drive belt bearings

As a result of wear in the bellows cantilever offset arm excessive vibration or bellows slap develops at high rates

SPECIFICATIONS OF COMMONLY USED RESPIRATOR EQUIPMENT

TANK RESPIRATORS

RESPIRATOR TRAYS AND HEAD ENDS ARE INTERCHANGEABLE IN THE SAME MODELS OF THE MACHINE IN AN EMERGENCY

Type	Drinker Collins Respirator*	Emerson Respirator*
Rate & Pressure Range	Rate 10-44 min Press +1 to +20 −1 to −30 to 35 cm	Rate 10-28 min Press +0 to +15 −0 to −30
Operating Voltage	110 V AC 60 cycle**	110 V AC 60 cycle**
Motor HP	¼th	1/3rd
Starting Amperage	8 4	11 2
Running Amperage	4 2 (includes light)	5 6 (includes light)
Recommended Fusing	20 amp	20 amp
Weight (lbs)	608	700
Height overall (inches)	58½	61
Width overall (inches)	31½	32½***
Length overall (inches)	75½	96
Operating & lubricating instructions	On the side	On the side near gauge
Emergency operation	Integral but must be assembled for use****	*Integral and immediately available*
Manufacturer	Warren E Collins Inc 555 Huntington Avenue *Boston 15 Mass*	J H Emerson Co 22 Cottage Park Ave *Cambridge Mass*

NOTE Values given for rate and pressure are variable and dependent upon the age and condition of the machine these are only average obtainable values encountered in ordinary use

Safety features	Simple hand operation Automatic alarm for power fail ure Has rate indicator	When used as a home model has automatic changeover from house current to battery Otherwise same as standard unit Shells of the Technicon Huxley generally have the greatest range of venti latory effectiveness	Will operate from 12 V DC source with converter e g automobile A spe cial wrap around shell and skirt are very effective but immobilizes patient	Simple reliable	Separate system for hand operation Utilizes electronic control for cycling which is relatively complex Proportion of inspiration to expiration can be ad justed Adapters for change of pressure curve are available
Curass sizes	Uses 4 sizes of flexible chest abdomen shells which are self sealing and have supporting feet which minimize pressure on the patient. Un comfortable in the sitting pos tion Special sizes on request Difficult to turn patient and main tain p essure in shell		3 sizes of flexible & moldable vinyl wire mesh con struction self seal ing chest abdomen shells especially valuable for pa t ents difficult to fit	Monaghan shells are available in opaque plastic and come in 11 sizes and 2 series The A series is particu larly valuable for the sitting patient. Seal is accomplished by an inflatable rubber edge	
Manufacturer	Contech Ltd Chauncey New York		J H Emerson Co 22 Cottage Park Ave Cambridge Mass	J J Monaghan Company 500 Alcott Street Denver Colorado	

Emerson Model CVI is a piston pump operated unit with integral hand operation
Manufacturer makes a positive pressure attachment and an abdomen belt respirator attachment
A scaled down version has been made for home and hospital use

Most manufacturers supply attachments which permit shells of these various respirators to be used either with the connecting hose or pump manufactured by their com petitor This makes possible virtually any combination of equipment for a particular need

All units supply a negative pressure range with a well fitted shell of between 0 and 40 cm of water

Rate of respiration on most machines cover the range from 8 or 10 to 30 or more cycles per minute Usually the same rate is used which has been comfortable in the tank respirator

SPECIFICATIONS OF COMMONLY USED RESPIRATOR EQUIPMENT

CUIRASS RESPIRATORS

Type	Technicon Huxley *Chest Abdomen Respirator* * Piston Pump				Emerson Chest Respirator Model CRV Portable	Monaghan Hospital Model Chest Respirator* * Piston	Monaghan Universal Portable Model Chest Respirator		
	Standard	Portable			Rotary Blower				
	Power Unit	Power Unit	Rectifier Charger	Battery	Power Unit	Power Unit	Power Unit	Charger for Battery & Battery Pack No 1	Battery Pack No 2
Operating Voltage	110 V AC ⅓ HP motor	24 V DC ⅙ HP motor	110 V AC	—	110 V AC	110 V AC only ⅒ HP 3 4 amp motor	110 V AC or 24 V DC ⅓ HP 24 V DC motor	110 V	—
Weight (lbs.)	76	81	39¼	69¼	37¼	200 (crated)	52¼	43½	33¼
Height (inches)	25	25	12	10	17	37	16	11	8
Width (inches)	17	17	10¼	9¼	16	20	12	8	8
Length (inches)	16	16	20	17¼	16	40	33¼	16	16
Emergency Operation	Intergral and immediately available				None, but has separate hand bellows	Integral must be assembled	Separate piston pump as part of machine shell connecting hose must be changed to a different pressure outlet		
Expected battery life for portable operation	Not applicable.	4 to 6 hours			Not available	Not applicable	4 hours		

Safety features	Simple hand operation Automatic alarm for power failure Has rate indicator	When used as a home model has automatic changeover from house current to battery Otherwise same as standard unit Shells of the Technicon Huxley generally have the greatest range of ventilatory effectiveness	Will operate from 12 V DC source with converter e g automobile A special wrap around shell and skirt are very effective but immobilizes patient	Simple reliable	Separate system for hand operation Utilizes electronic control for cycling which is relatively complex Proportion of inspiration to expiration can be adjusted Adapters for change of pressure curve are available
Cuirass sizes	Uses 4 sizes of flexible chest abdomen shells which are self sealing and have supporting feet which minimize pressure on the patient Uncomfortable in the sitting position Special sizes on request Difficult to turn patient and maintain pressure in shell		3 sizes of flexible & moldable vinyl wire mesh construction self sealing chest abdomen shells especially valuable for patients difficult to fit	Monaghan shells are available in opaque plastic and come in 11 sizes and 2 series The A series is particularly valuable for the sitting patient Seal is accomplished by an inflatable rubber edge	
Manufacturer	Conitech Ltd Chauncey New York		J H Emerson Co 22 Cottage Park Ave Cambridge Mass	J J Monaghan Company 500 Alcott Street Denver Colorado	

Emerson Model CVI is a piston pump operated unit with integral hand operation
* Manufacturer makes a positive pressure attachment and an abdomen belt respirator attachment
*** A scaled down version has been made for home and hospital use

Most manufacturers supply attachments which permit shells of these various respirators to be used either with the connecting hose or pump manufactured by their competitor This makes possible virtually any combination of equipment for a particular need

All units supply a negative pressure range with a well fitted shell of between 0 and 10 cm of water

Rate of respiration on most machines cover the range from 8 or 10 to 30 or more cycles per minute Usually the same rate is used which has been comfortable in the tank respirator

SPECIFICATIONS OF COMMONLY USED RESPIRATOR EQUIPMENT

CUIRASS RESPIRATORS

Type	Technicon Huxley Chest Abdomen Respirator** Piston Pump				Emerson Chest Respirator Model CRV Portable	Monaghan Hospital Model Chest Respirator Piston	Monaghan Universal Portable Model Chest Respirator		
	Standard	Portable			Rotary Blower				
	Power Unit	Power Unit	Rectifier Charger	Battery	Power Unit	Power Unit	Power Unit	Charger for Battery & Battery Pack No 1	Battery Pack No 2
Operating Voltage	110 V AC ⅛ HP motor	24 V DC ⅙ HP motor	110 V AC	—	110 V AC	110 V AC only 1/10 HP 3 4 amp motor	110 V AC or 24 V DC ⅜ HP 24 V DC motor	110 V	—
Weight (lbs)	76	81	39¼	69½	37½	200 (crated)	52½	43¼	33½
Height (inches)	25	25	12	10	17	37	10	11	8
Width (inches)	17	17	10½	9¼	16	20	12	8	8
Length (Inches)	16	16	20	17¼	16	40	33¼	16	16
Emergency Operation	Intergral and immediately available				None but has separate hand bellows	Integral must be assembled	Separate piston pump as part of machine shell connecting hose must be changed to a different pressure outlet		
Expected battery life for portable operation	Not applicable	4 to 6 hours			Not available	Not applicable	4 hours		

(4-6 hours) for the purpose of transporting patients and as a safety measure for power failure

The power unit and respirator are basically the same It uses a motor and gear box to move a piston in a large cylinder through a complete cycle thus developing both positive and negative pressure Valves are controlled by knobs on top to adjust negative and positive pressure The speed is regulated by changing the motor pulley ratio by using the knob on the side of the unit An electrical speedometer indicates the respirations per minute on the top of the machine

The 24 volt unit will operate from ordinary house current 110 V AC 60 cycles when used with the rectifier and batteries Simply plug the rectifier into a wall outlet plug battery and respirator into rectifier and it works as a straight 110 V AC unit The rectifier and battery should be plugged into the wall outlet at all times even if the unit is not being used to maintain a full battery charge

Maintenance suggestions

This manufacturer provides a telephone manual and operating service

Oil Leaks

There should be a breather cap on top of the gear box If not one will be supplied by the manufacturer If it has a breather cap and leaks obtain a new gear box

UNIVERSAL MODEL MONAGHAN PORTABLE

Description There is a dial type gauge on the front of the machine reading from 0 to 60 pressure and 0 to 60 vacuum in millimeters of mercury

This machine operates from a ½ HP high speed 24 V centrifugal blower with utilization of both suction and pressure outlets The pressure is changed from positive to negative by the means of a four way valve operated by an electric solenoid Rate and per cent of cycle occupied by inspiratory negative pressure are timed by an electronic device The amount of positive or negative pressure is determined by the amount of leak to the atmosphere through ports operated by adjusting knobs similar to those on other respirators

It is well to note that the hand operation is simple but the hose must be moved from its normal fitting and inserted in the emergency fitting on the front opposite end from the normal fitting Then simply pull the red handle up and down at the desired rate

GENERAL POINTS TO CONSIDER IN THE USE OF CUIRASS RESPIRATORS

Usually the chest abdomen type of shell (e g the Technicon Huxley) is best employed if available when the patient is first introduced to cuirass artificial respiration

There is very often a leak at the shell if a suitable pressure cannot be obtained The fitting and adjustment of the shell is a practiced art and familiarity with whatever piece of equipment is at hand is the most important consideration

Extremely high shell pressures may not be as effective as lower pressures if the patient s body touches the shell other than at the seal

The chest and chest upper abdomen type shells (e g the Monaghan A shell) are particularly useful when the respirator must be utilized for the sitting patient or when the patient is moved from tank to bed for example

These devices are not substitutes for the tank respirator except in emergencies In acutely ill patients they may be ineffective and their later use in early convalescence seriously jeopardized because the patient will not have confidence in them

Pressure adjustments are individual and may be critical because it is difficult to produce a mechanical adjustment which will cause a linear change in pressure for the revolution of the pressure control knob This does not mean a defective machine

LUBRICATION IS EXTREMELY IMPORTANT IN THESE DEVICES and should be carried out in accordance with the manufacturer s instructions

DO NOT TEST THE PRESSURE THE MACHINE CAN DEVELOP BY PLACING THE HAND OVER THE HOSE! Damage to the pump or the pressure gauge will result

DESCRIPTION AND MAINTENANCE OF CUIRASS RESPIRATORS

TECHNICON HUXLEY

Description This respirator comes in a standard 110 V AC unit to operate on ordinary house current and in a battery rectifier operated unit

SPECIFICATIONS OF COMMONLY USED RESPIRATOR EQUIPMENT

ROCKING BEDS

Type	Burns	Emerson Standard Hospital Model	Emerson Inter mediate Model	Emerson Home Model	McKesson Respiraid	Tomac
Motor HP	1/3	½	1/3	1/3	Special ½ DC	¼
Normal starting amperage	10	18	17	17	24	7
Normal running amperage	5 6	5	4½	4¼	8	3¾
Recommended fusing amperage	20	30	20	20	30	20
Weight (lbs) crated	300	480	345	340	550	700
Height (inches)	32	36	36	36	50	36
Width (inches)	37	36¼	35½	35¾	40	37½
Length (inches)	78	76	76	76	78	79
Range of rocking rate* *	12 28	15 26	15 26	15 26	0 30	10 30
Maximum inclination in degrees	50	60	60	60	60	60
Mattress	No	Yes	Yes	Yes	?	No
Manufacturer	C A Burns Co P O Box 1020 Denton Texas	J H Emerson Co 22 Cottage Park Ave Cambridge Mass			McKesson Appliance Co Toledo Ohio	American Hospital Supply Corporation 2020 Ridge Ave Evanston Ill

MAINTENANCE SUGGESTIONS

UNIVERSAL MONAGHAN

Study the manual BEFORE repairs become necessary

In rough handling or on land trips electronic components may vibrate loose It is simple to change tubes and relays since radio tube connections are used These parts are located on the back of this machine at the upper left Each one will fit only in the proper socket Check to see that the connections are tight

To change brushes in this machine read the manual or the instructions which come with the new brushes They will last a long time if installed properly

Cautions

Do not cover the ventilation holes on the outside of this machine with pillows or sheets otherwise overheating and damage readily occur

As with any chest respirator keep small children from dropping small articles in the hose outlets Results can be amazing Coins bobby pins even paint brushes have been removed from many chest respirator machines This hazard applies to all models by any manufacturer

HOSPITAL MONAGHAN

To eliminate noise on pulley at gear case apply one drop of oil on stationary end of end bearing surface while motor is stopped

To eliminate squeak of belt apply two eye droppers of any standard brake fluid to inside surface of belt while motor is stopped

For any other maintenance see manual or call nearest dealer

DO NOT PUT HANDS INSIDE MACHINE WHILE MOTOR IS OPERATING!

SPECIFICATIONS OF COMMONLY USED RESPIRATOR EQUIPMENT

ROCKING BEDS

Type	Burns	Emerson Standard Hospital Model	Emerson Inter mediate Model	Emerson *Home* Model	McKesson Respiraid	Tomac
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Recommended fusing amperage	20	30	20	20	30	20
Weight (lbs) crated	300	480	345	340	550	700
Height (inches)	32	36	36	36	50	36
Width (inches) *	37	36¼	35½	35¼	40	37½
Length (inches)	78	76	76	76	78	79
Range of rocking rate	12 28	15 26	15 26	15 26	0 30	10 30
Maximum inclination in degrees****	50	60	60	60	60	60
Mattress	No	Yes	Yes	Yes	?	No
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MAINTENANCE SUGGESTIONS

UNIVERSAL MONAGHAN

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In rough handling or on land trips electronic components may vibrate loose It is simple to change tubes and relays since radio tube connections are used These parts are located on the back of this machine at the upper left Each one will fit only in the proper socket Check to see that the connections are tight

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For any other maintenance see manual or call nearest dealer

DO NOT PUT HANDS INSIDE MACHINE WHILE MOTOR IS OPERATING!

Special Accessories for Rocking Beds

The Emerson alarm rings a bell or can be made to flash lights if the bed stops rocking

A piston pump connected to the bed synchronizes its action with the rocking Emerson offers these for operating a chest respirator cuirass and Tomac has a similar device A small bellows under the bed to give intermittent positive pressure to a mask or tracheotomy has been described

A remote control (low voltage) switch which the patient can operate by the touch of a finger (or toe) is sometimes useful Home patients especially may need this for starting and stopping their beds

Deckert 3 crank orthopedic bed tops are available on two Emerson models They provide a great variety of positions that are valuable in orthopedic care All new Emerson models have bed tops that permit hyperextension of the back

Lubrication instructions accompany each type of bed (Generally in the form of an attached metal instruction plate)

Cautions

Beds should be blocked so that they cannot creep while in motion thereby striking on a piece of furniture and causing damage to the end other furniture and the patient

NEVER ATTEMPT TO REPAIR OR LUBRICATE A BED WHILE IT IS OPERATING!

GENERAL DESCRIPTION—ROCKING BEDS

* Motors for all types of rocking beds are for 110 V 60 cycle single phase Alternating Current except when other characteristics have been specified

** Rocking beds are wider than ordinary house doorways For patients going home this problem can sometimes be solved by demounting the bedspring from the base (Emerson advertises this for Home Intermediate Models)

*** Respiration rates as set at the factory are shown in the chart above but on some beds faster or slower rates can be obtained by substituting a larger or smaller pulley on the motor shaft (or gear box) Adult size beds should seldom be run faster than 30 r p m because of vibration and strain Youth size beds are available for higher speed ranges

**** Maximum inclination includes both the head down and foot down sectors These may be equal but more often are predominantly foot down In most models the proportion of each can be changed by altering the length of the connecting rod In some beds (McKesson Respiraid and Tomac) a special control for this adjustment is integral and will operate while the bed is in motion

Much the same effect is obtained by gatching the head of the bed up or down However the arc through which thed iaphragmatic area moves may vary greatly in relation to the fulcrum of the bed Both comfort and ventilatory effectiveness must be achieved by careful individual positioning and mechanical adjustments

If the head of the bed is too high the patient s ventilation decreases (because of inadequate expiration) and strain on the motor greatly increases The patient should be properly distributed for balance on the bed Rocking is then smoother the motor draws less current and the patient breathes better

Unlike tank respirators which can be pumped by hand rocking beds provide no satisfactory means for hand operation in the event of electric power failure This is a danger that must be taken into account whenever a patient is fully dependent on the rocking bed (especially home patients) A manual breathing aid should always be available such as the Emerson hand bellows resuscitator

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An asterisk ( ) indicates reference to an illustration

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IN ERRATUM

Reference 29 on page 149 is in error and should be deleted

The asterisk (*) at the bottom of page 135 refers to the DOSAGE SCHEDULES on page 136

The brand name of Levofed at the bottom of page 56 should be spelled Levophed

The plus and minus signs before O on page 192 are in error

The page reference for "Signs of asphyxia" on page 41 should read page 24 instead of page 21

On page 159 in the third line of second paragraph the line should read "at 1 55 before taking patient off cuirass" instead of "off rocking bed